A DISSERTATION ON FIRE,

OR

MISCELLANEOUS INQUIRIES AND REFLECTIONS

CONCERNING

THE OPERATIONS OF THE

Laws of Nature;

WITH

AN APPENDIX,

CONTAINING

THOUGHTS ON MEMORY, REFLECTION, DECISION, MUSCULAR MOTION, &c.

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APOLOGY.

TO apologize for publishing new opinions and principles, avails little; novelty being considered, by a great share of mankind, an inseparable criterion of error or falsehood.

But it should be remembered, that, when the dawn of philosophy began to illumine the dark ages, and the splendor of learning to beautify the mind of the studious, every discovery was a novelty. But, that error and truth should be at that time in a greater or less degree inseparable, cannot be doubted.

Error, intermixed with truth, is no small embarrassment in the pursuit of further discoveries; the consequence of which has ever been, that the learned have been compelled to devote as much time to point out mistakes, that the way might become plain to further acquirements, as in search of the knowledge of abstruse matters.

Nor has the difficulty ended here—for the powers of the most penetrating geniuses are not sufficient, in all cases, to avoid error, even in this enlightened age. It behoves us, therefore, to examine with attention, and decide with candor, concerning principles, in all cases of importance. And what is there of more importance, than a knowledge of the causes and operations which produce, and destroy, all things on which our being and happiness depend ?

The writer trusts, that the candid, at least, to whose view these pages may come, will not, because the principles are new, withhold their attention ; but rather, that it may be an incitement to examine. For certain it is, that the knowledge of the Operations of the Laws of Nature is yet extremely imperfect ; and without proposing new principles, can never be otherwise.

It was by no means the intention of the author to censure the opinions of others ;

but he was, unavoidably, compelled, either to suppress his own, or dissent from many of those laid down by writers, whose characters and abilities he holds in the highest veneration.

Whatever is new in this work, is laid before the public for their decision; to whose candid judgment it will be cheerfully submitted; for the great tribunal will not eventually err.

Altho' the author has been, for forty years, in the habit of reflecting on the following and like subjects, yet, in consequence of crowded attention to many avocations, and the lengthy intervals unavoidable in writing, he could not, at all times, keep the various subjects sufficiently in view, to insure any great degree of correctness, or systematic connexion. And the great variety of subjects which must, necessarily, be considered, required the miscellaneous form in which it appears, to prevent being swelled to an undesirable size.

The different branches of science with which the various subjects are connected, have rendered the use of many technical terms unavoidable. The writer has defined some, and would have gone further, but for the fear of being thought pedantic. He takes the liberty to recommend to those unacquainted with it, *Quincy's Lexicon Physico-Medicum improved.*

August, 1813.

INQUIRIES

concerning

The Operations of the Laws of NATURE.

SITTING by the fire, the cold Christmas of 1811, in a room where much air was admitted, I observed the heat mostly carried up chimney. When the fire was brought forward, by larger wood, I further observed, that the particles or rays of heat, in spite of the pressure and current of the atmosphere, up the chimney, were forcibly projected into the room, so as to make it comfortably warm.

Upon which I queried in my mind concerning the source, essence and operation of this powerful, useful and comforting agent in nature.

After much study and mature deliberation, I became fully satisfied, that the sun is the source of heat; that the rays projected from the sun are the same, in essence, as those emitted from fire, kindled by art; and that the particles of light and heat are, identically, one and the same thing.

That the different operations of the Materia Solis* depend, 1st, principally, on a greater or less quantity passing through any given space, in the same time; that, when more collected, its operation is that of heat, but, when much more rare, that of light only, producing no sensible heat.

This appears clearly, when we observe the effects of the sun's rays; whose vivid force can hardly be endured by the naked eye, and whose warmth affords the greatest pleasure, even in the irradiated state in which they are projected to the earth. But which, collected by means of a lens, operate with power equal to the most intense fire. And, altho' when projected from the sun to the moon, and thence reflected to us, they are sufficiently collected for the operation of vision, on the very sensible retina of the eye, yet, when we consider the irradiated and diffused state they must be in, when they arrive at the moon, and that they again suffer like diffusion in

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* *i. e.* Matter of the Sun. It is intended, subsequently, to be made clearly to appear, that the expression is proper; that materia solis, rays of the sun, of heat, and of light, matter of heat, corpuscles, atoms or particles of heat, or of fire, and caloric, are all synonimous terms; and that anticrouon is only a power or principle, operated upon by that, which is properly expressed by any of the foregoing terms.

passing from the moon to the earth ; considering, also, the difference in the power required to produce the two effects, we need not be surprised, that, with the help of the best lens, no heat can be perceived.

These operations depend, 2dly, in some measure, and in some instances principally, on the manner in which the materia solis is disentangled and emitted from those bodies with which it is incorporated, by their accretion or growth, and in which it is a constituent material ; or from those in which, by some means, it has been more suddenly accumulated, and from which it more suddenly departs ; as heated iron, &c.

It is believed, the observable operations of the sun's rays above stated, will be conceded to. And can it be denied, that the essence of light and heat is one and the same ?

Hitherto our progress seems to have been free from any considerable embarrassments ; but we must expect to meet with operations of the laws of nature, over which the veil of obscurity is thickly spread ; and it will be very happy for us, if the veil of error does not obscure the truth, contemplated in our investigations.

Previous to an attempt to elucidate those operations of the materia solis, in which very considerable intensity of heat is experienced, without the appearance of light, and in which, as in many instances, light is discoverable where no heat can be perceived, (which, at first view, seems strongly to contradict the foregoing proposition) it is necessary to consider the Materia Solis as an element.

By element, is to be understood, a primogenial, uncompounded. elementary, component part of all the animal, vegetable, mineral and fossil productions in nature's kingdom.

Here then we have opened the gate to the general field of nature, whose laws and regulations are the reign and direction of "Nature's God;" where the most extensive finite capacity and comprehension are lost in unbounded infinity, and the utmost exertions of created, lost in the first attempt to scan uncreated power; whose existence, by this vast ocean of evidence, is irresistably impressed upon the philosophizing mind, and unavoidably leads to the most profound but silent heartfelt awe and reverence, for the great and unknown first cause.

However gratifying it might be to the inquiring mind to know and define the num

ber and quality of the elements, which seem to have been designed by an allwise Creator, as materials for the laws of nature to compose and set forth the beauteous and useful infinity of furniture which adorns the universe; yet, it seems not essentially necessary in this inquiry; and it is moreover probable that the attempt would be attended with insurmountable difficulties; and, as brevity is studiously sought, it is considered sufficient, briefly to notice some of the most conspicuous, and to us, most familiar substances; such as earth, air, and water, which have been considered by philosophers as elements; and to pass by others, such as sulphur, salt, oil, &c. it being undetermined concerning their possessing the properties of elements, or whether they are not themselves compound substances.

But, to support the doctrine, that fire is an element, and to explain its operations and effects, being the principal object of these inquiries, will claim minute and particular attention.

That earth is an element seems to appear from its being found among the fixed remains of most, if not all animal and vegetable substances, after a decomposition of their parts has been brought about by fire. But I know of no positive proof, that the ashes, so found,

are not every part of them a compound substance; and if compound, they cannot be primogenial, uncompounded, elementary substances.

That rocks, stones, gravel, &c. are compound substances, which, by the operation of the laws of nature, are subjects of accretion or growth, I have no doubt; indeed, there is such evidence as puts the matter beyond dispute; and that fire is a part of their composition, is evident from its being known to abound in them. Vegetables have often been found completely petrified.

I have been credibly informed of a butterfly, whose form and color was plainly distinguishable, composing a part of a solid rock, where it must have been for ages, and must remain as durable as the rock of which it is a part. I have, myself, seen numbers of vines of the evergreen kind, with their form and color perfectly conspicuous, forming part of a hard rock, blown out of a ledge, a considerable depth below the surface.

Innumerable instances of petrifaction are to be met with in the natural world; in addition to which a great number of other evidences might be adduced, but it is believed we have already enough to prove the accretion of fossil substances.

To prevent mistake, it may not here be amiss to observe, that it is not meant, that, at creation, there was nothing but primogenial, uncompounded matter furnished, and that thousands of years were required for the laws of nature, by slow degrees, to compose the vast varieties of compounds which adorn the world; but, that an alwise Creator, by his omnipotent fiat, finished the stupendous work, and beheld the universe, in all its beauteous order. To every part and particle of which was annexed, never to be altered, while time shall last, those rules, regulations, connections, and dependencies, which we term laws of nature; whose abstruse & mysterious operations, it becomes the philosophizing mind to contemplate, and, so far as may be, to explain.

It is presumed, that an uniformity in the operations of the laws of nature, will not be denied; and, that the operations and effects, which take place in the objects, which are conspicuous to our organs, may, with propriety, be supposed to take place, in those which are too minute for our inspection, or too slow for our observation.

In all the productions of nature, which are discoverable, we observe a time or season of growth, or arrival at maturity; a time of continuance in perfection, and a time of decay;

in which, sooner or later, a decomposition, and return of their component parts to their primogenial state, is effected.

It will, therefore, be assumed as a fact, that all which is produced by growth or accretion, is subject, not only to decay, but to complete decomposition; that, not only animals & vegetables, but rocks, stones, gravel, sand, loam, and clay, with many other earthy substances, are subjects of growth and decay.

All which, however, does not prove, that there is not a terrene or earthy substance, which is primogenial and uncompounded, and which may compose far the greatest part of the bulk of all fossils; and may, more or less, enter into the composition of animals and vegetables.

An opinion, therefore, that earth is, or is not an element, until further light shall be reflected on the subject, is suspended.

The next question is, whether air is an element, or not? Let it be previously observed, that whatever substance we are familiar with, which, upon close examination, pre-

sents to our view, no properties of a compound production, but, on the other hand, all the qualities and evidence which it exhibits, are such as ought to be received in proof of its being an uncompounded substance, will hardly be denied to be an element.

Correctly to form an opinion on the subject of air, it seems necessary, first, to understand its nature and properties.

A single atom of air is too minute for inspection, or for producing any sensible operation on our organs. Our observations, therefore, can be made, only on the effects of its particles, operating collectively; in which state it produces a vast variety, and from which alone we can conceive any idea of the form, essence and constituent powers of its particles.

Its extreme fluidity, as well as capability of rarefaction, plainly shows the minuteness of its corpuscles. To every particle of which, as the sole constituent power of its fluidity, there was, when created, annexed an invariable law of repulsion; by which power, they perpetually repel each other, so as never to come into actual contact.

Wherefore, air, although it may be intermixed, entangled and confined with other el-

ements, composing solid substances, in the form of animal, vegetable, and fossil productions, of which it makes a part; yet, when it is the greater part of the composition, it can never become solid, like water congealed.

This law of repulsion may be greatly increased and extended by the existing power of many operations in nature; but by no one else, near so much, as by that of fire; by which extension, the particles irresistably recede further from each other.

The plain consequence of which must be, an increased rarity and expansion of the volume thus operated upon.

Familiarly to exemplify this; suppose a cistern partly filled with ounce balls; they can form but a partial fluid. But suppose an invariable law of repulsion to be annexed to each ball, by the power of which they must recede a quarter of an inch from each other; yet, notwithstanding, this power, by force of violence, may be crowded upon, and the balls come nearer together; but never so as to touch in any points; nor ever to cease exertions to regain that distance.—Nothing can be plainer than that the mass must be greatly increased in size and become extremely fluid.

But instead of ounce balls, suppose the mass to be composed of the finest shot, and without the power of repulsion. Touching in many more points, it seems it must be much less fluid; but upon the application of the law of repulsion, diminished in the same ratio as the balls are supposed to be in size, the fluidity would therefore be increased.

In either of the foregoing, if the idea of the repellant power suffering partial depression, like an elastic atmosphere, is kept in mind, nothing can be more easy than to conceive the principle of fluidity. Suppose, for instance, a pound weight, dropped into such a body contained in a large cistern; it appears clearly that the mass must be all thrown into agitation; for if one ball is pressed deeper into the mass, it will move all adjacent, which will move the next adjacent, until the whole are disturbed.

Some idea of this may be conceived by observing the needle of a compass, which, when undisturbed, remains quietly submissive to the power of polar attraction; but when violently forced from its obedience to the law of nature, seems "tremblingly alive" to regain its place in creation.

Of the various inventions hitherto suggested to account for fluidity, no one appears

more specious than that roundness, smoothness, hardness, homogeneousness and minuteness of the corpuscles, are sufficient to constitute fluidity ; and that the mass must be more or less fluid, according to the degree in which its particles possess these qualities.

For solidity depends solely on the cohesion of attraction, which is increased or diminished in proportion to the number of points in which the component parts touch.

But as two balls, when in contact, can touch in one point only, (which point or space of contact is as large between two of the least imaginable, as between those of the largest size) and to constitute a perfect sphere or ball, perfect smoothness is requisite ; and to retain its figure, impenetrable hardness is equally necessary—and because a mass of homogeneous balls will touch in less points than an equal quantity composed of those which are of unequal sizes, it seems clear, that particles, possessing the four first-mentioned properties, are calculated to compose a mass which shall touch in less points than any other figure or property possibly can, the power of repulsion excepted.

But each such corpuscle, touching in four points only, (for they can touch in no less) instead of composing a fluid, especially, if to

the four above-mentioned, the fifth, property of minuteness, be added, it would probably form a solid, as hard, brittle and pellucid as glass. Were it even granted that the composition would be fluid, yet it would lack some of the essential properties observable in fluids, as rarefaction and exhalation; and if the foregoing reasoning be admitted, concerning the cohesion of attraction, the finer the particles, the greater must be the attraction; wherefore, minuteness, instead of tending to fluidity, must greatly increase solidity.

Therefore it seems extremely difficult, if not impossible, to account for fluidity, without admitting the aid of the law of repulsion.

Nor does it appear that a spherical figure is, in the least, essential to fluidity. For the same principles which are admitted as sufficient to account for the fluidity of air, must also be admitted to account for the same property in water and all other liquids.

Judging from the operations and effects of aquafortis and many other liquids, which appear as transparent and fluid as the purest water, we cannot, I think, suppose the corpuscles composing them to be spherical; but that they are as pointed as the laws of nature could form them.

For they have the power of destroying, in a short time, the hardest steel.

But I will not deny that this may be performed by some other property than pointedness of particles.

However, I know of no reason why we should doubt the spherical figure of the particles of air.

Although the particles of air are extremely small, yet it seems to appear from experiments, that those of electrical fluid, fire, water and oil, if no more, are still finer. But, however the fact may be, (and the truth of it is not altogether essential in these inquiries) I am not without doubts, concerning water, oil, &c.

For, notwithstanding they may be pressed through the pores of gold, it may be owing to the much greater power of irresistable repulsion which the corpuscles of air possess, over and above those of water, &c. that renders it impossible to force air through gold.

If the foregoing reasoning is correct, the great body of air seems to be made up of globular corpuscles, which are, so far as yet appears to be ascertained, the finest in creation, excepting

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fire; there being doubts concerning those of water, oil, and several others.

The specific gravity of air greatly exceeds that of fire, (if fire is at all within the power of common gravity) and much exceeds that of electrical fluid, and seems to be the same with that of the matter of cold, but lighter than any other substances whose gravity has yet been ascertained.

Each corpuscle of it possesses a much more powerful and extensive law of repulsion than those of any other fluid; on which alone collectively depend its superior fluidity, rarefaction, elasticity and transparency.

That air is an element seems clearly to appear, from observing a variety of the operations of nature.

That it is an ingredient in the composition of most, if not all compound fossil substances, appears probable, from its being diminished when exposed to petrifying substances—for petrifaction is not simply the changing or turning from one state or mode of existence into another form, but requires addition or privation of matter, or both the privation of one sort and the addition of another. To transform water to ice requires the addition of the pa

It is not the less probable that rocks and other fossils have air in their composition, because they were formed at creation; for all things were created with their components, as complete as those which are produced by growth.

All animal and vegetable bodies, upon a decomposition of their substances, produce a portion of air. If those bodies are not partly made up of air, whence comes the air they afford? No one will suppose it to be formed or generated by the destruction of those substances.

Acids and alkalies, when mixed, mutually decompound each other, and much air is emitted.

But a total solution and decomposition of their component parts does not take place—for although they lose both their forms, and the nature of such existences, yet, from the remains of both, a tertium quid (or third substance) is suddenly produced, but in all respects different from either of them, and the emission of air is always in proportion to the quantity of matter decompounded.

So in fermenting liquors, the crude vegetable matter, possessing acid and alkalescent qualities, suffers decomposition; in which

operation it emits much air, and a tertium quid called spirits is formed or grows out of the dissolving substances.

That the juices of fruits, farinaceous substances, &c. contain oxygen, all will admit; and that they contain the principle of alkali, will as readily be admitted. Considering they possess incipient acid and alkali, and also from the similarity of appearance in the effervescence of fermenting liquors, and mixtures of acids and alkalies; it appears reasonable to conclude, that acids and alkalies produce the vinous, if not most or all other kinds of fermentation. For acids and alkalies possess such an antipathy or repulsion to each other, that after once coming into action, they never more rest together, but support perpetual war till one or both are destroyed.

But, if any one supposes that fermentation ought to be attributed to some other cause, I shall not contend on that account.

Many other arguments could be used to elucidate and support the proposition, that air is an element; but those already produced are thought sufficient; and prolixity would be insupportable to a reader who finds little to attract his attention.

To establish the position, that air is not itself a compound substance, it seems sufficient to show that it exhibits no evidence to prove itself such; but negative proofs by the rules of law are hardly admissible.

If air is a subject of growth and decay, *i. e.* if it is compounded by the operation of the laws of nature, of a variety of primogenial, elementary substances, (which were provided at creation, for the purpose of composing the productions of nature) and consequently subject to decay; is it not a little surprising, that philosophers, before now, should not have discovered some time, place or mode of its formation; or, that it should not have been discovered in its decaying, or decayed state. But there is no evidence that any such discovery has yet been made.

That portions of the circulating, atmospherical air are entangled and combined with other elementary substances in the productions of nature, where it becomes fixed; and that the great volume of moveable air is proportionably lessened, is not to be denied.—But this change of situation lessens not the quantity of air in existence; and when, upon a decomposition of some productions of nature, the fixed air in it is set at liberty, the volume of moveable air is augmented in pro-

portion; but the whole quantity of air is not increased.

When reasoning upon air, it ought to be kept in mind, that it is the essence, properties and effects of pure air, which employ our attention—for no part of the atmosphere is ever found free from impurities, but an inconceivable variety of extraneous substances are continually wafted with it.

As the design of these inquiries is to search for truth and not error, it belongs not to this work to censure the opinions and writings of others, nor (if the writer's abilities were equal to the task) to attempt to confute them.

But, with deference to the high authority of the characters, with whom it has fallen to his lot to differ in so many important points, he begs leave to suggest, that air, loaded with extraneous substances, (as above-mentioned) has erroneously been considered a new compound production, formed by the operations of the laws of nature.

That such an error should take the place of truth, where the least haste in forming an opinion has happened, ought not to surprize us, when we consider the vast variety and

important operations those extraneous matters produce.

Some being so extremely deleterious, as to prove instantly fatal to those who are so unfortunate as to be exposed to their effects; others most disgusting to the olfactory nerve; others, by stimulating the same nerve, excite to action the whole system, and restore to life the body to appearance dead, and others imparting the most agreeable sense of pleasure, through the same sensible nerve of the nose.

And as some things (especially fire) have the power of rarefying air to a very extraordinary increase of its medium volume; so, also, some things, and especially the fumes of carbone or charcoal, heat to redness, (or, to speak in modern style, carbonic acid gas) have the power of condensing air, and reducing it almost to a fixed state, whereby it is rendered incapable of supporting life.

I have said the fumes condense it; for it would be most extraordinary if burning coal, than which nothing has greater power to rarefy air, should absorb it, as we are taught by respectable authority to believe. And how a few handfulls of burning coal can absorb the greater part of the air contained in but a small room, surpasses the power of im-

agination to conceive. For this comparatively large volume of air must be reduced in size, so as to occupy no more space than the pores or interstices of the coal afford; which, when we consider the shrinking of the wood, and consequently closing of the pores in the act of coaling, we must allow to be but small.

But cold carbone neither absorbs nor condenses air.—It must then be condensed by somewhat emitted from the coal whilst undergoing decomposition by the operation of fire; as it must be attracted to the coal and sufficiently condensed, to enter its substance, by that which not only repels air, but above all other things, rarefies it, viz. by fire.

Though we are (as before remarked) informed, by highly respectable philosophers, that burning charcoal absorbs air, this opinion, (doubtless given without sufficient consideration) it is presumed, is abundantly shewn to be erroneous; and that the air, instead of being absorbed by burning coal, is condensed by certain exhalations from the coal, whilst suffering decomposition by the operation of fire.

We are further told, when charcoal is fully consumed by fire, that, (this must undoubtedly mean some part or all of the ele-

ments of which it was composed) by combination with oxygen (or the principle of sourness) and caloric, (or the principle of heat, latent heat or fixed heat) it turns to carbonic acid gas; which is said to be the heaviest of aeriform fluids; and that by its great weight, it sometimes settles into mines, caverns, wells, &c. where, from its fatal effects, it is denominated choke-damp.

Passing silently over the idea of those combinations, not fully comprehending them, permit the question, whether, in this case, the effect is not mistaken for the thing?

If the foregoing arguments are correct—if the exhalations from burning charcoal have the power of condensing air, which it is thought will not be denied—if such exhalations, floating in the air, render it highly mephitic or deadly, which experience has often taught; and as the specific gravity of all bodies is increased in proportion as they are condensed, [*i. e.* if, without diminution of matter, a mass is reduced to one half its volume, it is plain that a cubic foot will weigh double what it would have done before its reduction] is it not clear that it is not a new production, in the form and appearance of air, (called carbonic acid gas) which so operates as to produce the above effect? And also, that it is not burning charcoal which eats up

or absorbs a part of the volume of air, so diminished and seeming to be lost ; but that it is what is liberated by the operation of fire from the carbone while consuming, that has the power, and does condense and reduce the volume of air with which it intermixes.

Again, is it not certain that air, so condensed, (by the fumes aforesaid) has lost its life-continuing power, and is thereby totally fatal, without any other septous quality, operating directly on the vital organs ?

The thing beforementioned is the fumes of burning carbone or charcoal, (or carbonic acid gas ;) the effect is, that the air is condensed, becomes inelastic, heavy and incapable of supporting life.

If we inspect water in its various appearances, except when congealed to ice, it exhibits to our view a transparent, elastic fluid; but its transparency is greatly short of that of air : the reason of which is obvious—for the specific gravity of water is, to that of air, nearly as one thousand to one ; consequently, the density of water is nearly one thousand times greater than that of air ; and therefore,

water must be about a thousand times less pellucid.

But the rays of light being almost infinitely finer than the particles of air or water, far the greater part of them pass through the medium of air without interruption, by striking against its particles; yet some of them are refracted and reflected, in consequence of hitting, as appears by viewing the atmosphere in the twilight; for though we discern not the sun, we behold a luminous appearance.

But water is so dense as to reflect the rays of light, in some measure, as powerfully as a solid substance. The great density of water, to that of air, is also evident, from its imperfect transparency—for, notwithstanding the particles of water are, by the law of repulsion, kept at sufficient distance from each other, to afford passage to the rays of light through a small volume of it, so as to exhibit distinct vision while in a quiescent state; yet the least agitation renders vision imperfect, and if violent, produces total obscurity. But the vacuities in air are so great as to afford ample passage for the rays of light to convey distant vision, although agitated by the most violent whirlwind.

So, also, the density of water appears, in its congealing to ice, by the admixture of the matter of cold.

But, clearly to understand the operations of freezing, it seems necessary to have a correct idea of the essence of cold.

It is considered warrantable to decline subscribing to the doctrine, that cold is only a negation of heat; (though adapted by many) which is saying that cold has no existence. To suppose that negation, nihility or nothingness can affect or be affected, can occupy space, or suffer change of place, is absurd.

If none of the foregoing qualities can be applied to cold, we ought not to say it is cold, but it is not warm; nor that it is frozen, but it is extremely not hot!

That cold is opposed to heat, is agreed; and that they are common enemies, ever counteracting and repelling each other.

That cold repels heat, is evident from the excess of heat near a fire in extremely cold weather, when we evidently find it much more confined and accumulated where the air is highly charged with frigid matter, than when it is freer from such matter.—

Also, a hot iron discharges its heat faster, when placed a proper distance from a fire, than when placed in a cold room; and many more examples to the same effect could be mentioned.

That heat repels cold, is evidently shown, by a very simple experiment.—Put snow or ice (sea-salt added increases the operation) into a pewter bason, which place on a pewter plate, with water in the plate; set them near a large fire, but not on a hot hearth; stir the snow or ice in the bason; from which, while melting, the particles of cold will be forced through the bason, and congeal the water in the plate, the bason and plate being frozen fast together. In this process it is plain that the corpuscles of cold are repelled by the heat of the fire, from the bason, into the water in the plate; else, whence comes it? Will any one say that a negation or want of heat left the bason, went into the plate and there congealed the water to ice?

Does water depend upon heat for its fluidity? If so, the warmer the water, the more perfectly must it possess that property. But we can discover no very great increase of fluidity when it is near boiling.

It is true, oils and fat substances discover an increased fluidity, very quickly, upon the application of heat; but these possess this quality in but an imperfect degree, and require the agitating principle of fire, to excite into operation, the small portion of the power of repulsion which their corpuscles possess, to enable them to show any considerable degree of fluidity.

Nor is it denied, that water, when violently agitated by fire, becomes almost (perhaps quite) as fluid as air. But this all does not prove that a mere negation of heat congeals water.

Again; let one, compressing a snow-ball in his hand, hold it over a large fire, the hand will freeze before the snow is melted; and the nearer the fire the sooner the effect.

From the foregoing and other like operations, is it not plain, that cold itself operates in one place, and is capable of being transported to another, and there again operates; and that it is not annihilated or destroyed, any more than fire; but is repelled by fire? If so, its properties are those of a real entity quite the reverse of negation or nihility.

It seems enough has been said to prove the existence of cold, the admission of which is

essential in explaining the operation of freezing. Indeed this operation seems conclusive proof that cold is an entity.

The process of nature, in changing water, by cold, from its fluid to a solid state, has by some been considered obscure and mysterious; and I know of no satisfactory explanation having been hitherto advanced—it is, therefore, with diffidence, now attempted.

It is necessary to observe, that the small degree of elasticity and rarefaction (unless produced by the greatest violence) to which water is subject, are proof that its particles possess a power of repulsion, sufficient only to prevent them from touching in any points, so that its fluidity should not be imperfect; and consequently, that the interstices between them are extremely small, though large enough freely to admit the frigid salts (called cold) to pass amongst them. That the particles of cold pass freely amongst those of water, is plain, from the great degree of cold which water quickly acquires, when exposed to an atmosphere highly charged with them; as well as from another fact, viz. that an ice is sometimes first formed at the bottom of rivulets, called anchor-frost. This last is also proof that water does not repel the matter of cold.

To understand the operation of freezing, it also seems necessary to consider the law of attraction.

It is a maxim in philosophy, that matter attracts matter—and notwithstanding fluidity depends upon repulsion, yet this maxim applies as well to fluids as solids; for the power of repulsion, which constitutes fluidity, seems strictly bounded, unless increased by violence; and its increased operation is in exact proportion to the violence exerted.

The repellant power of the particles of fluids, in a natural state, has not the least operation beyond its bounds; without which, attraction takes place. This admits of occular demonstration in a variety of ways. To mention one—a drop of water, on a plain, forms almost an half sphere, and when disfigured by violence, it regains its form by its own power.

It is doubtless true that the power of attraction, possessed by the particles of any matter, is in proportion to their distances; consequently, the attraction, when the particles touch each other, (termed attraction of cohesion) is extremely powerful. The hardest steel, or diamond, owes its resisting power and solidity to cohesive attraction.

Two corpuscles of matter touching each other, will continue in contact to the endless ages of eternity, unless separated by violence.

This power of cohesive attraction, is the rule of God, or law of nature ; and its mode of operation is as unseen and as inexplicable as the Great First Cause who produced it.

Our minds, from constant familiarity with matter, are struck with an idea that it is something necessary and independent ; but attentive reflection will soon make it appear plain to us, that matter, and the laws by which it is governed, are both equally dependant on the Creator.

An adamantine rock does not derive its solidity from screws, rivets or hooks, but solely from attraction.

From what can be discovered, it seems evident that the atmosphere is the great habitation or magazine of cold ; but that it is communicable to all other bodies, fire only excepted, when they approach a column of air in which it is stored.

That the Sun is the source of heat, is not perhaps denied by any one.—It seems equally necessary there should be a residence found for cold—and we have no proof of its

being a foreign substance ; but from many observations, it appears evidently confined to our world.* If so, it seems its great residence must be the air or the earth.

The air, as high as our observation extends, exhibits incontestible evidence of its possession. The sense of feeling experienced in ærial voyages in balloons ; and mountains covered with eternal snow and ice, are conclusive.

But the earth shows no signs of possessing cold, except what is communicated to it from the atmosphere. In the parts of the earth nearest the air, cold most abounds : otherwise of the air—the nearer the earth the less cold.

That there is no frigid matter, deep in the earth, is demonstrated in a well, at Amsterdam, of extraordinary depth, in which, neither heat nor cold exists ; the mercury always standing at the same degree.

* It is often ſaid of ſome of the planets, that they are "exceedingly cold ;" but thoſe philoſophers ought to recollect that if no cold was depoſited with them at creation, nor any ſince generated, they muſt be without it.

That the matter of heat penetrates some depth into the earth is evident from an observation (if well founded) concerning cellars, in which, when plastered (than which, perhaps, nothing of the same thickness more powerfully resists the passage of heat and cold) from about the surface of the earth upward, the effects of frost are prevented; but when plastered also downward, to the bottom of the cellar, the effects of the frost are evident, from its destructive operation on the culinary matters placed there for safety.

Also, from an observation in ice houses; where, it appears, ice, placed in winter, remains congealed through the summer and till the surface of the earth is sealed by frost, in the winter following; when it is soon dissolved, and returned to its fluid state.

The same operation of heat produces the effect in both the above cases.

The particles of heat or fire, which, the preceding summer, had penetrated into the earth, and are slowly emerging again in the winter, are stopped at the surface of the earth, which then is rendered impervious to them, by frost. They, then, take a lateral course, the way where they meet the least resistance; and when they are not resisted by the plastering, find easy admittance into

those cellars; where they repel the particles of cold which had been admitted, through the floors, &c. from the atmosphere above, and prevent the operation of freezing. But, when the plastering extends from the surface of the earth downward, to the bottom of the cellar, those emerging particles of heat are thereby obstructed from entering the cellar, and there preventing the damage of the frost.

At the ice-house, the emerging heat, finding no resistance, easily enters, repels the frigid salts, and dissolves the ice.

It also seems evident, that the specific gravity of the matter of cold is the same as of air.

That the higher regions of the atmosphere are always highly charged with cold, I do not consider as any proof, that the matter of cold is lighter than air; but that the rays of heat, passing directly through those regions are insufficient to repel the particles of cold from their high abode.

For ice may be formed into a lens, by which the sun's rays may be brought into a focus, without operating very much on the ice so formed. And further; the sun's rays at the surface of the earth, where they are accumulated in sufficient quantities, repel the corpuscles of cold, and drive them upward.

An attempt has been made to prove that cold is not a negation, but an entity. The power of attraction has been considered.—Arguments have also been used with a design to make it appear, that the interstices or vacuities between the corpuscles of water are extremely minute—that water does not repel the particles of cold—and that the specific gravity of the matter of cold and air are the same; all which seems necessary to be understood and admitted, in order to understand and explain the process of congealing water to ice: and it may not be amiss to observe that no substance is susceptible of freezing, except water, or that which contains an aqueous fluid, in which the fluid alone receives the frost.

After all these considerations, is it a hard thing to conceive that when a volume of air, charged with frigid matter to the freezing degree, comes upon the surface of water, it will discharge, to the water, sufficient frigid particles (for the thermometer proves, that the degree of heat and cold will, in all cases, shortly come to the same in air and water, which are adjacent) to fill the vacuities, in the water next the air, so that the corpuscles of cold and water may touch (for the repellant power, which keeps the corpuscles of water from touching one another, is not calculated to repel those of cold, but admits

them within the sphere of repulsion) in points enough to cohere and give solidity to the compound of cold and water, or in other words, to form ice?

Can any conceive that merely depriving the water of heat can congeal it? If there is such an one, a little reflection may convince him of his error; for there is a state that is neither hot nor cold, but totally indifferent to both—this is demonstrated by the well (beforementioned) at Amsterdam, of such depth that the mercury in the thermometer always stands at the same degree.

The vast depth of this well prevents the materia solis from ever reaching its bottom, consequently there is a perfect negation of heat.

And if cold is only a negation of heat, this must be the coldest place throughout the world; but fact shows it to be otherwise.

Something similar to this well (though less perfect) are cellars made for guarding against excessive cold and heat; in which the degree of heat and cold does not differ greatly in summer and winter. Those who adopt the doctrine that cold is only the negation of heat, ought to let their principles and conduct agree, and not put their vegeta-

bles, designed for use in winter and spring, into a room or cellar sunk into the earth, fortified with a wall, the wall banked with gravel without, and plastered within, and the whole covered with a house! and all for what? to exclude and prevent the entrance of that which they deny has an existence! (*i. e.* cold.)

And will not this equally prevent the entrance of heat? And the more perfectly the heat is excluded, certainly the more intense must be the cold, if this doctrine is true.— But, if they act according to their principles, they will place their vegetables on the highest ground, uncovered, that there may be no obstruction to the reception of heat: for admitting the truth of the doctrine, which excludes the existence of cold, they need not fear any damage from its power in any situation.

From all of which it seems that it is not the want of something which congeals water; and if it is not the want, it must be the addition of something.

If so, what can be the added matter but cold?

For cold, when accumulated to a certain degree, never [illegible] effect

which nothing but cold ever does produce ; nor that, in any substance, except water.

The increase of the volume of water produced by freezing is another evidence of the proposition, that particles of cold are employed in the operation. That water swells nearly in proportion to the quantity of the matter of heat it receives, and lessens again as it parts with it, is too obvious to be denied.—That water swells by freezing, is equally obvious. How absurd then to say that water lessens in bulk, in proportion as it is deprived of heat ; but when greatly deprived, its bulk is thereby increased.

This is a language which cannot be disconnected with the idea that cold is nothing but a negation of heat. Errors admitted for truths, necessarily lead to absurdity.

No one will argue that the absolute gravity of water is diminished by freezing, (*i. e.* that a pound of water will weigh less after it is frozen) which it must, if its bulk were increased without the addition of matter.—But the writer hazards an opinion, that it will weigh more than a pound after freezing, provided that no part of the water evaporates or is exhaled, which it may do, either before or after being frozen, if not closely covered.

Again, if water were increased in volume without the addition of substance, it must necessarily become specifically lighter; for specific gravity generally depends upon the quantity of matter contained in a given space —therefore, if a pint of water should be increased in volume one eighth, without any addition of substance when weighed in the air, it must have lost nearly one seventh part of its specific gravity; *i. e.* if its heft, before increased, was eight ounces after freezing, one pint only will weigh but seven and one ninth.

But if the supposition is true, that the matter of cold and air are of the same specific gravity, and the addition of one eighth should be of the matter of cold; then, if weighed in the air, its specific gravity will be altered in a small degree from what it was before the addition; but its specific gravity to that of water will be materially altered.

Let a pound of water freeze, and weigh the whole bulk in its increased state, and (the particles of cold being of the same relative gravity as the air in which it is balanced) it will weigh the same as before, with the trifling addition of that portion of the matter of cold, which, without aiding to increase the bulk, finds room in the before unoccupied interstices, and this small increase of heft

wouid be but just discernable ; when, if its bulk were expanded without the addition of matter, it would be proportionally lighter.

Plainly to exemplify this subject, suppose a bladder, which in a colapsed and empty state will measure one cubic inch, to weigh an ounce in the air ; distend it with air, and its heft weighed in the air will not be altered—it will still weigh an ounce : but, in water, (although it would have sunk when empty) the increase of bulk will be material ; instead of weighing an ounce, it will buoy up a pound weight.

This diminution of specific gravity is strikingly exhibited in the vast islands of ice which are seen floating, in some instances, in the northern seas, rising sometimes fifty feet above the surface of the water : and experience has taught that ice projects about one tenth part of its thickness out of the water in which it swims. But to determine accurately, water's increase of volume by congealing, is not an easy matter ; for the empty spaces between its corpuscles will receive some of the matter of cold, which will augment its gravity without adding to its volume.—Again, the ice which is forced above the surface, by the superior gravity of the water which the part under the water receives ; that above be[illegible]ported by the

atmosphere only, which is nearly one thousand times lighter than water, adds further to the difficulty.

Nor will any argue that the specific gravity of water congealed, is diminished by being deprived of heat ; for it is evident, from observation, that the specific gravity of water is diminished, in proportion to the quantity of heat applied to it : nor have we any evidence that the matter of heat is in any measure subject to the common law of gravitation.

The state in which living animal substances and vegetables appear, which have undergone the destructive operation of frost, adds another strong proof of the truth of the foregoing proposition.

Upon examining a bed of cucumbers after a frosty morning, a variety in the operations of the frost on the different plants may be discovered.

This is owing to the state of the plants when the matter of cold is applied ; for the plants, whose sap-vessels are most distended, by absorbing the dew with which they have been covered the preceding night, will suffer the greatest injury, (and probably some of them are in a state much more favorable to inhalation than others) the destructive ef-

fects of frost, being in proportion to the fulness or distension of the sap-vessels of the vegetable which suffers freezing.

This is plain, from observing, that no dry substance suffers by frost ; and we see some plants which exhibit no apparent marks of injury, (yet may have suffered latent mischief) although equally exposed with those that are totally destroyed.

The more or less the sap vessels of the tender plants are filled with fluid, the greater or less quantity of frigid salts they will receive ; and they will also be proportionably dilated, by the intervention of the matter of cold, by which those tender vessels must, in like proportion, be torn, burst and destroyed ; and we find some of them quickly showing every mark of decomposition—all of which is produced by the operation of the matter of cold within the substance of the plants ; for they sustain no injury from the dew which is congealed upon their surfaces.

The reason we do not find destructive effects, produced by a cold morning, succeeding a night in which they have not been moistened by the falling dew, is because the sap-vessels 'are but partially filled, and their coats in some measure colapsed, wherefore they [illegible]tion of their

contained fluids without suffering laceration, and in such an unmoistened state may possibly survive being frozen to stiffness.

It ought to be observed that they may suffer as much injury by the expulsion of the matter of cold, as by its entrance, in the operation of freezing ; for when the sun's rays strike with considerable force at first, the particles of cold are suddenly driven and crowded more strongly together in some parts, which are more forcibly distended than before. Again, in this hurried state, they may be forced back into a part from whence they were previously driven, and again congeal the sap within the before injured vessels, which, in this second operation, are much more liable to injury than at the first.

Much of the foregoing is somewhat exemplified by the operation of frost in a potatoe ; than which, no vegetable perhaps is more filled with aqueous fluid, and consequently, none more suddenly suffers perfect decomposition by freezing.

Yet, notwithstanding, the frozen potatoe, if rightly managed, may answer a useful purpose for food.

This depends on preventing further destruction to t tance,

by extracting the matter of cold, and also, hindering what has already taken place from increasing.

Put the potatoe, when frozen hard into water, possessing no particles of heat, and less cold than is sufficient to congeal it.—The particles of cold at the very surface, first spontaneously recede from the potatoe, into the water; for by the laws of nature, by which they are governed, they are compelled to be equally distributed to every part of the aqueous fluid, in which they reside.

At first, suddenly rushing from the potatoe, they congeal the water adjoining, and form round it an icy shell, which quickly checks all hurry in their discharge; hence those further back, pass slowly through the open ways, but just left by the preceding particles.—In the same manner the rest proceed, until the corpuscles of cold are all discharged quite to the centre, and by this precaution, are transmitted through the substance of the potatoe, without further lacerating and injuring it.

After which, allowing no time for putrescent solution of continuity, (ever ready suddenly to begin, in such a lacerated and broken state of vegetable substance) let it be instantl [illegible], there to under-

go sufficient decoction to prepare it for food, and it will prove pleasant and salubrious.

Another method is, to cast the potatoes, frozen, into boiling water. In this operation, although the texture of the sap-vessels of the potatoe is much more broken, by the sudden and confused movement of the matter of cold from its confinement in the congealed substance than by the former process; yet the instantaneous application of heat, to such a degree, resists all tendency to putrescency, and prevents any further destruction of the vegetable substance. But the former method is thought best.

The effect of freezing in living animal flesh, is, perhaps, a total destruction of the skinny, muscular and vascular substances, as deep as the fluids contained are perfectly congealed.

An expansion of those fluids is produced in the same manner as has been observed with regard to frost in vegetables, by which, those very fine and tender vessels are so lacerated and wounded as to prove fatal to them, and which must, faster or slower, occasion a total decomposition ; the matter gradually sloughing off, and leaving an ulcer to granulate and cicatrize.

The art of treatment consists, principally, in such management as may prevent the corpuscles of cold from penetrating deeper, when they come to be operated upon and repelled by the particles of heat, which alone can be safely applied from within the body: indeed the great art consists in preventing any heat from operating outwardly.

This method, experience has long since established; but the practice has been altogether empyrical. In consequence of the idea prevailing, that cold is not an entity, and being guided by no theoretical principles, many errors in practice have taken place.

The treatment prescribed, has been to immerse the affected part in cold water, or otherwise to apply to it, or to rub the part with snow or ice; but without any knowledge concerning their operation, or being able to give a just reason why these more than any other things should be useful; yet, the practice has in many instances proved extremely salutary. When the whole matter is understood, it is an easy thing to prescribe accurately.

Since we discover, from so many operations, that cold is a real entity, and understand the manner in which it operates to congeal aqueous fluids, and that it is repelled by

the particles of heat, it is easy to conceive, that when a part of the body is frozen, if heat operates outwardly on the affected part, it must drive the particles of cold deeper into the flesh; but if it operates from within, it will expel them from it.

It is then plain, that to prevent the heat from operating without, (and that, before the part is exposed to the air of a warm room) it should be covered with water possessing less cold than is sufficient to congeal it, but entirely destitute of particles of heat, that they may not drive the particles of cold deeper into the flesh, and that all resistance to their exit outwardly, should thereby be prevented. In this state the internal heat of the body will repel the frigid matter from the congealed fluids outwardly, which meeting with no resistance at the surface, will pass off without further injury to the parts.

That snow or ice should never be used in cases where water cannot be had, or cannot be applied for want of conveniences, I will not positively say,; but if they are used, the patient must not come into an air warm enough but slowly to melt them; for if they thaw, the particles of cold must go somewhere, and in all probability they will be repelled to the flesh, to which the snow or ice

is applied, and instead of relieving, will increase the malady.

Should any one doubt this, let him try the experiment (before-mentioned, page 32) of the ice in the bason, set into a plate containing water, and he will be convinced that the heat from the fire repels the matter of cold through the bason, into the water, which he will find congealed, near a hot fire—or let him continue to hold snow in his hand, within the influence of such a fire, and his hand will freeze—(see page 33.) Why may not the frost be as well increased by a similar operation, on the part already frozen, as in the above experiments?

If in a forest, or an uninhabited road, or in any other similar situation, the weather being intensely cold, one should be frozen, would not the application of snow or ice, without doubt, increase the frost, as much at least as the cold air which it is designed to exclude? If so, there would be an impropriety in the application.

But, if a spring, unfrozen, could be found, the application of the water would be proper, unless the part must again be exposed to undergo the operation of freezing, and in such a case, all wet applications had better be omitted.

Again, if snow is applied to a frozen part, in an air sufficiently warm to dissolve it externally faster than the warmth of the body does the congealed fluids within the part, I think it is clear that the frost in the flesh will be increased by it: and if the air is so cold as not to dissolve the snow, then the air will do no injury and need not be excluded by any application; (for it is warmth only that is to be guarded against) therefore, the snow is unnecessary. Upon a full view of the matter, I much doubt the propriety of ever applying snow as a remedy in a case of frost.

Ice is sometimes formed in situations indicative of great singularity; sometimes falling from the atmosphere in irregular and large lumps, and sometimes formed at the bottom of rivulets, and even small rivers.

In attempting to explain the operations of nature in forming hail, some particulars, which at first view, may seem not closely connected with the subject, require attention.

The water, which is the principal ingredient in the composition of hail, is exhaled

from the earth, the ocean, and other collections on its surface.

The operation of exhalation is somewhat obscure; but it seems effected principally by the action of fire, the agitation of the air or wind, and by fermentation; all of which appear to perform their office by violence: from which agitation and disturbance, the repellant power annexed to the particles composing the water, is excited to an operation far beyond the common bounds, and extended to such a degree that they occupy a space sufficient to cause them to agree in specific gravity with air.

A want of sagacity, too common to mankind, appears many ways; but in nothing so much as in not discovering and admiring the wisdom of omniscience displayed in the beautiful and harmonious works of nature!

It seems evident that the corpuscles of which water is composed, are perfectly uniform in size, form, density and gravity; and that in their natural state, the power or law of repulsion which constitutes fluidity, is, in its extent, also perfectly uniform; (that their distances from each other may always be exactly the same) and also, that their repellant power has no operation towards many, if

towards any substances, except air and each other.

Wherefore some quantity of many substances is admitted among them without the least increase of volume, and some of the first importance to man and beast. In water, the particles of cold, fire, &c.—in air, almost innumerable matters: all of which only fill the empty spaces or vacuities necessary to the operation of those elements, into which they are admitted: by which provision, there is a perfect plentitude in creation, and yet the fluidity of water, air, &c. is sufficiently preserved, to answer the purposes for which they were designed; and by the uniformity abovementioned, the transparency, &c. of water and air are much more perfect.

Again, to come more directly to the point in question, the rarefaction and exhalation of water depend entirely upon an increased or extended operation of the aforementioned power or law of repulsion. In this, again, we discover a beautiful uniformity; for the purposes of exhalation could not have been answered, had not the specific gravity of the exhaled particles of water been brought to, or very near that of air—and from every observation that comes into view, it appears that the repellant power of each particle, is

capable of, and when excited, does increase to exactly the same extent ; so that the particles composing the exhaled water, (now called steam, vapor, fog, mist or cloud) possess an uniformity in all those particulars already observed in water before its exhalation.

It has been mentioned that fire is one of the principal agents in producing rarefaction. —Let us consider its operation in a vessel of cold water placed over it. Soon after the fire begins to affect it, a vapor arising from the water, is discoverable ; which is produced by the operation of the fire, exciting the repellant power which the corpuscles of water possess, to an extent far beyond its natural bounds, when quiescent. This steam, together with a gradual swelling of the volume of water in the cistern, increases as the heat in the water accumulates.

All the foregoing operations seem to be brought about in the following manner :— As soon as a sufficient quantity of the corpuscles of fire have penetrated through the cistern, the repellant power of some one particle of water begins to be extended, which particle, thereupon, instantly becomes an attractor of fire, whereby it impels, within its aforementioned sphere of repulsion, as many of the particles of heat as its attractive power (which operates on fire only) requires ;

which particles it has sufficient power to retain, till the design of their accumulation is answered : (and the purpose of this may be various ; perhaps, principally, to distil in showers of rain, that the earth may be productive, &c.) This accumulation of particles of fire, preserves the rarity of the exhaled particles of water, by which they continue to move with the air in which they float, till by some inexplicable operation of the laws of nature, they are collected into close order, so as to form clouds ; which, when thus collected, and a cold stratum of air is suddenly mixed with the warmer in which they float, are condensed in the same manner as the exhaled vapor, from the boiling copper, is, by the coldness of the worm of the still.

Although we can assign no reason why the operation of cold does not condense the exhaled particles when scattered remotely from each other, yet the reason why it should so be is obvious ; for if as soon as an exhaled particle approached air, charged with cold, it must be condensed and precipitated singly to the earth, it seems we should seldom, if ever, have showers of rain ; for by the collection of those particles, clouds are formed, from which the rain descends.

Dews only, night and day, would be all we could expect; which, in summer, in days when the sun shines with vehement heat, (and no clouds to shade the earth could be expected) would exhale nearly as fast as they would fall.

But the matter of heat is not the only agent which causes exhalation—it has been observed that fermentation and agitation of the air produce it; so, also, do all kinds of agitation. Let a bottle, filled with hot water, be violently shaken, and the pressure within shows a great degree of rarefaction of the contained fluid.

Yet, we have no evidence, nor does it appear probable, that the exhaled matter, produced by these last, where fire does not aid in the process, ever is carried high in the atmosphere, but that it is soon precipitated insensibly, by night and day, in form of dew; though in the day it is again so suddenly exhaled by the operation of the sun's rays, that we do not perceive it.

The exhalations from cateracts, where a large volume of water falls with great violence on cragged rocks, is very great, but seems quickly precipitated in form of spray: although wafted with the wind many rods, and at l[illegible] carried miles;

yet we have no evidence that any part is applied in the formation of clouds, or distilled in regular showers of rain.

It seems probable, that in all instances, as soon as an extension of the repellant power of a particle of water, when excited by fire, begins to take place, that extention is instantly carried to its utmost limits; (for the particle of water now becoming an attractor of fire, as soon as the operation begins, immediately attracts to itself its full supply of the particles of fire, if sufficient number are within its power) and that, till thus extended, not the least rarefaction of the other particles composing the volume of water takes place.

This rarefaction occurs, not in one corpuscle only, but in an inconceivable number, at the same time.

It is plain, if the occupancy of a single particle is extended a thousand times beyond its former space, that the whole mass will be swelled as much as that particle occupies more than before; and when the operation takes place in millions of millions, it may become perceptible.

When we consider that the specific gravity of water is to that of air, nearly one thousand to one, it is [illegible] water,

before it can float in air, must become nearly one thousand times lighter ; to produce which, it must occupy nearly one thousand times more space than before—and when thus lightened, the surrounding unrarefied water, must, with the greatest force, propel those rarefied particles to the surface, and powerfully project them from the mass ; and this in a perpetual increasing shower during the increase of heat. By this operation the greater part of the matter of heat which is applied to the water is removed from it ; each rarefied particle carrying along with it all the heat which it has attracted within its sphere of repulsion ; hence the propriety of covering a cistern to hasten its boiling.

Nothing therefore is plainer, than that exhalation, beyond any other process, exhausts the matter of heat from any substance in which it is accumulated.—And this, constant experience also demonstrates ; for the warm breath from the lungs, destitute of cold, blown upon hot tea, by agitation, cools it ; so indeed does shaking the cup of tea. The smith wets the iron which has become hot, that it may exhale steam, to cool it : and so with innumerable other instances, within the observation of every one. But the thermometer decides with the greatest accuracy ; which being placed in a proper situation to show [illegible] [illegible] [illegible] [illegible] [illegible] -et the bulb with

water, and while it is exhaling from the surface, the mercury within will sink some degrees, and after the exhalation has ceased, will rise again to the degree at which it stood before wetting: but if highly rectified spirits, which will exhale much faster, are used instead of water, the mercury will sink much lower.

Hitherto we have considered the operation of water, when acted upon by a small degree of heat; but when the accumulation of fire in the interstices of the water is so great that the mercury rises to the 212th degree, on Fahrenheit's thermometer, the operations are so increased, as to exhibit very different appearances. Nor can art (although invention should be exhausted, to apply more heat under and around it) augment the heat of the water in an open vessel, beyond the aforesaid degree; for when it rises to the 212th deg. the water is saturated with fire. All further additions of its particles are instantly applied in rarefying or extending the power of repulsion of particular corpuscles of the water, to which the superabundant particles of fire are instantly attracted, (as before explained) and as suddenly, by the force of gravitation, expelled from the remaining mass.

This operation, taking place in an innumerable quantity at the same [illegible] uses

that violent agitation, called boiling: and although the exhalation of but one particle, augmented to nearly a thousand times the size of the remaining, and forced through and from the mass, must produce an ebullition, yet no apparent boiling takes place short of the above degree, when the ebullition becomes general.

Notwithstanding the impossibility of increasing the degree of heat in water in an open vessel, yet, in a vessel in which the steam or exhaled matter can be confined, (such as Papin's digester) a quantity of heat may be accumulated, sufficient to melt lead, tin, &c. suspended in the midst of the water, and, in a short time to boil bones, &c. to softness.

And we need not be at a loss where the heat from an open vessel goes. Let one apply his finger to the aperture, in the cover of one of Rumford s boilers, when in operation, and he will be convinced what becomes of the heat.

This rarefiable property of water, when thus acted upon by fire, is the power by which the steam engine moves the wheel with such force; which, when the principle is generally understood, promises great benefit to mankind: especially in those parts

where competent streams of water are not to be found—a power which may be continued without great expence, and wants only the ingenuity of the mechanic, to enable it to perform those operations, which, by the usual modes are extremely slow, painful and fatiguing to animal bodies.

The preceding facts, established by experiments, seem conclusive evidence of the correctness of some of the foregoing hypotheses; especially those concerning the manner in which exhalation is effected, the rarefaction of the exhaled particles continued, &c. &c.

Water thus combined with fire, and exhaled, becomes what is termed gas, elastic fluid, æriform fluid, or elastic vapor; of which chymists tell us there are a great variety: and, according to their mode of distinction, they may as well tell us at once that the variety is without end!

Notwithstanding it has been considered that no particles of water, exhaled without the aid of fire, are ever long suspended, or carried high in the atmosphere, it is not intended that the exhalation for that purpose, must in all cases be performed near a burning fire. The matter of fire directly from the sun, and the particles of fire f... sub-

stances, of which it is an elementary component part, (when by solution of continuity, some of their component parts are scattering in air, and some falling to the ground, and the particles of water are rarefying by fermentation; which ever takes place where putrefaction is progressing, whether in animal or vegetable substances, and probably in all others—the particles of fire being by the same destructive process set at liberty) are as ready to be attracted by the particles of water rarefying, as in the cistern aforementioned; and the exhaled particles of water are thereby as well supplied with the particles of fire, as those which exhale from the cistern where fire is the sole agent.

But when compound substances are dissolving and their component parts returning to their native state, the decomposition is not suddenly perfected; the exhaling, watery particles, carrying along with them more or less of the partly decompounded materials of the putrefying or otherwise dissolving substances; and as these matters are innumerable, the gases, (as they are called) will also be innumerable in their operations on our senses, and also in their effects; some being destructive to life, &c.

It seems there are some matters which mixing with exhaling aqueous fluid, serve

to combine the fire, which it attracts much more strongly, and cause some of those gases to become much more permanent than others : still, considering them only as exhalations, I can see no reason why they should be accounted ærial substances, more than the effluvia of a rose which floats in the air.

We are told that water makes air ; but I believe the only way in which it is changed into air has been explained in accounting for exhalation, and that when again condensed, it is as much water as if it had not been rarefied.

That water seems to be transformed to air, may be seen in many operations. The appearance of bubbles of air may sometimes be seen at the bottom of ponds, where the mud is composed of putrefying vegetable substances.—But those bubbles are filled only with the particles of water, rarefied to the lightness of air, (as before explained) by the fermentation in those dissolving substances ; or they may be filled with real air, which has been set at liberty from those decaying substances, and confined by some viscid or slimy matter from the same source, strengthened by the equal pressure of the water on the surface of those bubbles ; which air, finding no avenue by which to escape, underneath their bases, is confined, until by a disturbance, the

water ceases to press equally upon them, when they burst, and the superior gravity of the water forces the lighter fluid to the surface. But the most perfect likeness of air occurs in water, while agitated by the greatest ebullition over a fire, when it appears to be only bubbles of air. But the fact is, there is not a single particle of air in it; for air, in its mean state, is nearly a thousand times lighter than water—and though water is capable of being rarefied, in its utmost extent, to about the same specific gravity of air on its medium, yet, to rarify it to the appearance of bubbles of air, (as above) requires a degree of heat, which would rarefy air probably to more than one hundred times its medium state; when, if but five times more, the particles of air would become nearly five thousand times lighter than those of water. By such inequality of specific gravity, the heavier would project the lighter from among them, with inconceivable velocity!

If there is air in water, from whence is it derived? and how is it admitted? are questions worth attention. Will any one say, that a lighter substance will spontaneously sink down into another, five thousand times heavier than itself, where there are no interstices to receive it, but which it must make by force of its gravity? For experiment shows there are no vacuities among the corpuscles

of water sufficient to receive air—as water may be forced through gold, but air cannot; and yet water is nearly one thousand times heavier than air. Is it possible then there can be vacant room among the particles of water sufficient to receive air? Again; from a state of coldness, it needs no other operation but that of fire, on the water in the cistern, to produce the appearance of air-bubbles.

From what has been already remarked, it seems clear, that air does not descend from the surface into the water: nor will any one hazard an opinion, that it passes through the cistern; for whether made of gold, silver, copper or iron, the effect will be the same on the water. Many other arguments, to prove that water contains no air, could be adduced.

It seems that the striking likeness which water, when rarefied to exhalation, bears to air, has led many into the error, that there is air in water, and that water may be transmuted to air; but experiment shews that altho' it appears to be changed to air, it is easily returned to its primitive state.

It has been mentioned that exhalation is also produced by the operation of the wind. This takes place in the coldest weather, and even from water congealed to ice.

We ought not to be surprised at the idea of the exhalation of ice; for if the power of the wind exceeds the attraction of cohesion between the outer stratum of the particles of water composing the ice, and the corpuscles of cold which are wedged in between them and the next stratum of particles of water, it is easy to conceive that the cohesion by which the outer stratum of particles of water are held, will be broken off, and those particles go adrift in the wind; and perhaps more readily when the water is congealed, the particles of water being then raised asunder by the intervention of those of cold; and when the outside layer of particles of water are gone, there is nothing to hold the outer layer of particles of cold, now exposed naked to the power of the wind, except the slighty contact of each one, touching in one point only: doubtless, it is as natural for them to let go that small cohesion and float in their own element, the air, as to remain inactive; perhaps much more so.

It is a common saying among those who are in the practice of washing and drying clothes, that they will freeze dry in cold weather; and I think it is probable they will dry faster by the operation of the wind, when frozen, than when not—for (as before observed) when frozen, the corpuscles of water are raised further apart, than when unfrozen,

and if once stirred by the wind, they are perfectly at liberty; but when not frozen, altho' the volume of water is almost infinitely less than the eye can discern, yet there may be eddies and whirlpools, both upon and within the threads composing the cloth; and notwithstanding all this commotion, the attraction of particle to particle, and of particle to the cloth, may, in a great measure, resist the power of the wind.

But water possesses a property almost diametrically opposite that of rarefaction, and one which is peculiar to itself; which is that of congealing to solidity, by the admixture of the matter of cold, as before-mentioned.—This, in cold climates, is common; but there are some instances in which (even in such regions) it appears singular. It sometimes descends through the atmosphere in large irregular lumps, and is sometimes formed at the bottom of brooks and small rivers.

In attempting to explain the operations of nature in the production of hail, some things which seem not altogether connected with the subject, require attention.

The operation of exhalation has been much dwelt upon, and an attempt has been made to prove the combination of fire with the exhaled particles of water, for the purpose of continuing their rarety, till they are collected in the form of clouds, in a proper situation to be (by another power) condensed, &c.

From observing the operation in a worm of a still, it is plain that such combination cannot resist the power which cold possesses, to condense such exhalation; it seems necessary, therefore, to show that the exhaled particles of water are (by an alwise provision in the arrangement of the works of creation) continued in a warm volume of air, although carried high in the atmosphere, until it is proper for them to descend in the form for which they were designed.

No one will dispute the perpetual existence of cold, high in the atmosphere; but that there are several strata of warmer and colder air, one above another, may seem hard to demonstrate; yet, without such, there can be neither hail, snow or rain, and when properly attended to, it may appear as easily produced as any other operation of nature; for we are certain, from observation, that laterally to the earth's surface, there is such variety.

We also know that the air is never quiescent, but continually suffers intestine motion; and that air is rarefiable by heat and becomes lighter in proportion to its rarefaction.

Let us then suppose a volume of air, one hundred miles square on the earth's surface, and one mile in depth, and that it is warm and rarefied, the northerly part adjoining a cold and condensed air, and a like air resting upon it above; is it not easy to conceive that the heavy air on the north will press under the lighter. which must consequently be raised? suppose a strong southerly wind drives the warm air northward; will it move on the surface of the earth? certainly not; but take a course angular to the earth's surface, of about five or ten degrees elevation, according to circumstances; nor will it suddenly mix with the circumambient, cold air.

Two volumes of fluids, unless forced by violence, mix but slowly, even in small vessels; as may be seen by pouring milk into a cup of tea; which, if poured moderately, and not agitated by stirring, will take considerable time to mix.

The light volume of air, more especially if the pressure northwardly continues, will wholly rise into the atmosphere.—And when

highly elevated, may not another proceed in like manner? and in time, may not the latter come directly under the former; and by such position, there be two warm volumes, with a cold one between them? which, with one cold below and one above, will amount to five cold and warm lamella, one above another.

It is a fact that air does not powerfully retain the materia solis, which may be seen by inflating a bladder; which, when the air within is made hot, remove into a cold air and it soon parts with its heat.—And if what air will fill a bladder will cool in a second of time, sixty times the quantity will require a minute to cool; and by this rule, such volume as has been described will require years.

Fire is the essence of heat, nor have we any warmth or heat beside. The sun is the source of fire, from whence alone it is derived.

When the matèria solis (or rays of the sun) are projected from their source, with inconceivable celerity, (as is ever the case) to the extreme limits of the earth's atmosphere, some of them at first, and more in their passage through it, are refracted and reflected; but for the greatest part pass free-

ly through the ample vacancies among the particles of air.

And it is altogether probable that those which meet with obstruction are not resisted by the particles of air, (which seem not to admit the particles of fire to come into contact with them—for if the rays of light were admitted to strike generally upon the particles of air, the whole atmosphere, when shined upon by the sun, would appear like one vast cloud, glowing with fire) but are turned in their course by the resistance they meet with from extraneous substances; a vast variety of which float in the interstices between the particles of air: thus swiftly passing in unceasing showers through the air, as they may through a lens formed of ice, without the operation of warmth, (except those which are refracted) to the surface of the earth, which (being there accumulated) they warm, and also heat and rarefy the air next to the earth; and that at all times, when the heat from the sun is not counteracted by cold.

Hence it appears, that it is not a few solitary volumes of warm air, which once in a long time, rise into the atmosphere, (as before explained) but that the air, next the earth, is daily thus warmed, rarefied and made light, and consequently daily rising into the atmosphere. And fire being a prin-

cipal agent in producing the exhalation of water, both effects therefore spring from the same source; and these warm volumes of air, elevated as above stated, are always highly charged with watery exhalations; which, when collected near the surface of the earth, (and so as to become visible) are called fog; but if high in the atmosphere, clouds; both of which are identically the same in essence —the different appearance we seem to discover, depending entirely on the different situation.

When a warm lamella of air, thus charged with watery exhalations, is elevated high in the atmosphere between two colder, by the attraction of particle to particle, or by some operation yet unknown, they are so far collected as to occasion the appearance of clouds; and when more collected, the clouds appear thicker and darker, and by violent agitation of the air, the colder and warmer lamella are suddenly mixed—and so great is the opposition or repulsion which heat and cold bear to each other, that when thus suddenly mixed, a continual roaring may be heard from the clouds resembling distant thunder: this always denotes the falling of hail, though in some instances it seems to have been congealed and again melted in its descent, as appears by a few extraordinary large drops of rain which sometimes fall

when the roaring in the clouds is heard, and no real hail is discoverable.

That this roaring is the effect of mixing heat and cold, a simple experiment will show :—into a kettle, containing eight or ten pails of water, boiling with greatest agitation, pour, at once, a pail of cold water, and a similar roaring, for a time, may be observed.

By the sudden mixture of cold, the vaporous cloud is condensed in the same manner as that which arises from a boiling copper is, by the cold in the worm of a still ; when it returns to the same specific gravity as water unrarefied, and falling with great celerity, the originally small drops attract one another in their descent, and if they do not meet with cold to congeal them, fall in form of drops of rain.

But below this warm stratum of air, where the clouds are condensed, there may be another stratum where intense cold abounds, and through which the falling drops must pass : no one will doubt but in such passage, they must be congealed to ice.—The only difficulty lies, in conjecturing how they can acquire such bulk as they sometimes exhibit ; for it is certain that they begin to fall the instant they are condensed, there being no power in the clouds to suspend any thing

heavier than air. (It is childish to suppose fish, toads, worms, or any reptiles descend from the clouds ! !)

Although the largest hail generally falls when the air is hottest near the earth, it is probable, at the same time, there is a cold stratum but a small distance above, and that the warm stratum, in which the exhalations are raised and condensed, is of great depth ; that the condensation, also, is very rapid, and the condensed drops very numerous ; which, by attracting each other, suddenly become large, and perhaps increase in size faster after they begin to congeal, than before ; for their irregular appearance plainly shows that some of them are made up of a number of small ones, congealed together, which once congealed together, cannot be separated by the force or resistance of the air.

Again ; there can be no reasonable doubt, that during tornadoes, the air in those higher regions is as violently agitated with convulsive eddies, as at the surface of the earth. For tornadoes (at least sometimes) begin among the clouds and descend to the earth : and credible report pronounces, that they have, after producing destructive effects, risen in the atmosphere, carrying with them many things which they had taken from the earth, which they let fall many miles distant,

and where no uncommon agitation of the air had been perceived.

Certainly such violent currents and agitation are sufficient, in part, to prevent the perpendicular descent of the commencing hailstones, and carry them in a lateral direction, as well as to whirl them about with eddies, by which their fall may be retarded and time given for their enlargement.

And also their heft and solidity will check their swiftness in the wind, whilst the lighter acqueous particles are moved with superior velocity; by which, not only the condensing particles and smaller drops will be continually blown against them, but the smaller hailstones also; all of which, when they touch, will instantly congeal fast to the larger ones, by which they must be suddenly increased in size. Considering every circumstance; rather than wonder that they are so large; is it not more surprising that they do not become larger?

We know of nothing positively useful to mankind in the production of hail, but its origin denotes the reverse. The terrifying convulsions of nature, which threaten destruction to the world, at the time this substance is formed, and the desolating effects which mark its progress on the face of the

earth, clearly evince that it is sent, in judgment, to affrighten and punish mankind for their crimes.

Snow is as perfect ice as hail; yet proves, in many respects, highly useful.

Its form plainly shows its production to be in a pleasant and tranquil state of the atmosphere; for, unlike hail, (large, irregular lumps of ice, sufficient to destroy man and beast) snow is composed of innumerable small icicles, which are congealed as soon as condensed, and gently attracting each other, (like all other crystalline bodies, when forming, or like those which are formed by condensed exhalations, on glass windows, when the weather is cold) their points coming in contact, are gently supported by cohesive attraction. The flakes thus loosely connected, are like sails spread, ready to waft with the wind.

Extraordinary occurrences cause surprise and excite curiosity to the highest pitch.—Every mind becomes inquisitive to discover the mode of operation, and learn how those things are formed, in a sudden and unnatural way; which, when produced by the common course of nature, are as familiar as other matters in general. Such are the following:

Mon. Chaptal, in his "Elements of Chymistry," vol. 1, page 151, relates—"On the 20th of October, 1786, a dreadful shower of hail fell at Montpelier. A druggist, who was in his cellar, to prevent mischief, occasioned by the filtration of water through the wall, was highly astonished to behold that the water which came through the wall was instantly changed to ice." He says—"I visited the place a quarter of an hour afterwards, and found ten pounds of ice at the foot of the wall: I was well assured that it could not have passed through the wall, which did not exhibit any crack, but appeared to be in very good condition. Did the same cause which determined the formation of hail, in the atmosphere, act equally in this cellar? I relate the fact, and forbear to make any comments on it."

M. Chaptal also gives a numerous catalogue of extraordinary occurrences—the following are a part of them, (other particulars do not come to mind) viz. A shower of fire and brimstone on Sodom and Gomorrah—a shower of sand, of many hours continuance, on the Mediterranean—the falling of stones, minerals, &c. in divers countries, of which, North-America is one mentioned.

Although they fill us with astonishment, yet, it is probable they may be made to ap-

pear less surprizing. For before the dawn of philosophy illuminated the dark ages, (and still, by untaught savages) eclipses, earthquakes and volcanoes, among many other things, were considered as totally unnatural, and nothing short of the frowns of the Great Author of Creation, on a guilty world; but since, by the aid of philosophy, their causes are discovered, and their production by the laws of nature ascertained, though sublimely awful, the astonishment is lessened.

The foregoing extraordinary phenomena must be ascribed to the immediate operations of Deity, in miracle, or to the regular operations of the laws of nature. Concluding that they may be accounted for in the natural way, the consideration of miracles is left to those, whose province it more immediately is to expatiate thereon.

To avoid errors, in attempting to account for the foregoing appearances, it seems necessary to reflect, a moment, on the operation of the law of gravitation.

We are taught, by uninterrupted observation, that all ponderous substances, whether higher or lower in the atmosphere, without exception, gravitate towards the centre of the earth; at least, we have no evidence, nor do we make any discoveries to the contrary.

It is true, that the heavier of two bodies (*i. e.* the one possessing the power of gravitation in a greater degree) will retain its place, and force the lighter to remain above it: this is more apparent in fluids, or a mixture of fluids and solids. A ball or shell may be sent upwards, by the explosion of gun-powder, in a mortar, &c.—a stone may be projected perpendicularly from the hand —or the most ponderous substances may be supported by pillars, shelves, or other resting places; but, as before observed, we know of no power in the atmosphere unagitated by tornadoes, &c. nor any thing thereby suspended, that can retain, in air, any substance, a cubic inch of which contains more matter than a cubic inch of air.

Nor are stones, minerals, or any fossil substances ever observed to be suddenly produced—indeed, their growth or decay, within, or upon the earth, which is the natural situation of their production, is so exceedingly slow, as to be but just demonstrated by human observation. It must then seem absurd to suppose, that such substances are suddenly, and in a natural manner, produced by some chymical commotion of the elements, in the atmosphere; which, if admitted, must, at the same time, be considered unnatural.

If the preceding reasoning is admitted, the doctrine of air-stones, &c. must vanish.

Concluding that the foregoing are not miraculous productions, and are not suddenly produced in unnatural places, the facts at the same time being admitted, it seems necessary to attempt to account for such phenomena, in a satisfactory mannner, by the laws of nature.

And have we not numerous instances of occurrences more extraordinary than any of the foregoing, which are so amply attested, as to leave on the mind no doubt of the truth of their existence ? have not Islands been thrown up in the midst of the ocean ? have not large cities been deluged and covered deep, with melted lava, cast forth from the bowels of the earth ? have not enormous mountains been formed by the general contents of the earth, from the same source ? and have not huge rocks, stones and fossil substances been exploded to amazing heights, and fallen to the earth at vast distances from the place of their eruption ? is it then a hard thing, to suppose that stones, minerals, and fossils should be thrown from the earth, because a continual volcano is not in the neighborhood ? may there not be an explosion for once only, or for once in centuries, and the place of eruption be discovered by no one ?

might not a shower of sand, on the Mediterranean, of hours continuance, be exploded from the bottom of that sea, in a direction to be favored by the wind, and fall at such distance from the place of its eruption, that those who were within the circle of its fall, could not discover its rise ? and might it not happen, that no others should be within observation of its exit from beneath the water ?

And are we absolutely obliged to believe that (as was believed, at that time of ignorance, by all the inhabitants of the country round about it) to have been a shower of fire and brimstone, which destroyed the cities of Sodom and Gomorrah ? would it be immoral ; or would it, in the least degree, savor of disbelief of Sacred Writ, to suppose that they were overflowed with melted lava, as many cities, in other parts, have since been ? is there not enough uninhabited land in the United States, or even in Connecticut, for the stones, &c. which were there discovered to fall from the atmosphere, to have been exploded from the earth, unobserved ? and is it strange, that the place from which they were exploded, should not yet have been found ? or might they not have been thrown from under the sea ? and may not the same observations apply to all others of the kind ?

That compound of the matter of cold and water, called hail, is quite another matter.

The congealing of water, by the admixture of cold, is not uncommon in cold climates, and that, too, suddenly; and in any place where water and sufficient cold come in contact: even boiling water, thrown a distance into the air, when highly charged with cold, returns to the earth, congealed to ice. Such an appearance, at the equator, would, however, be extremely surprising.

There appears no analogy in the formation of hail and common stones, minerals, &c.—therefore, admitting the formation of hailstones in the atmosphere, affords no proof that those other substances are therein formed.

The foregoing extraordinary account of water, freezing on the inside of a cellar wall, in the heat of summer, where it would not have frozen in winter, upon reflection, may appear not at all surprizing: for, if a quantity of hail or ice, from an ice-house, is placed against a cellar wall, of stone, and not too thick, on the southerly side, where the sun may shine unobstructed, and the wall, on the inside, is kept wet with water; but there need be no water applied, for the coldness of the wall will condense sufficient, that is ex-

haled and floating in air, to form ice: if, in all respects, the experiment is properly conducted, the water sprinkled on the inside will not fail of being congealed, in the hottest day.

If, at all times (the weather being hot) when we are provided with a quantity of cold, united to water, we may by art, cause the cold to be transported, from the congealed water on one side of the wall, through the same, to water on the other side, with which it will unite and congeal it, is not all surprize done away?

And this exactly agrees with the experiment heretofore mentioned, of freezing water before a hot fire, or freezing the hand, compressing a snow-ball, in as great heat as can be endured.

To account for the production of anchor-frost, it will be necessary to call to mind some observations which have heretofore been made.

The following particulars are assumed as facts:—the various strata or lamella of warmer and colder air (before suggested)—the entity of cold—that the matter of cold and fire powerfully repel each other—and that the matter of cold has free passage through air and water.

It is believed also, that anchor-frosts are commonly (if not always) produced, when the air is very little agitated with winds.

Let us then suppose, in winter, when the weather is severely cold with us, and the air quiescent, that a volume of warm air, at the southward, has gradually risen into the atmosphere, and by the pressure of southerly winds has come northerly and rests over us, but a small distance from the earth, between which and the surface of the earth and water there is (as before observed) a severely cold but shallow stratum of air ; is it not easy to conceive that the particles of fire, in the warmer stratum, will repel the particles of cold in the colder, (on which it rests, and with which it is mixing) with great velocity, downward through the air, to the surface of the water, and through the water to the bottom ? where, being accumulated in sufficient quantity, they will fill the interstices between the particles of water, and between the lower particles and the materials on which they rest, and there congeal them together, and also, to the stones, gravel, &c. at the bottom ? in this situation they must remain fast-anchored, until the sun comes to shine into the water ; its rays will be accumulated at the bottom in sufficient quantity to repel the particles of cold and set the ice to floating ; and this accumulation of heat will be

also quite to the lower extremity ; for ice, unless thick, is too porous to obstruct the particles of fire altogether.—Or it may be set at liberty by any power sufficient to break its cohesion from the stones, gravel, &c. at the bottom.

This collection of ice at the bottom of water, seldom if ever takes place, except in the night.

Dams have sometimes been raised by the collection of anchor-frost on the rolling ways, where the water passes over, to such height, as to endanger the dam, by the consequent accumulation of water in the pond.

Mills have been often stopped in the night, by its collection at the gate-ways.

Water has still another property of such vast importance in creation, that it ought not to be overlooked ; that is—its solvent power ; for it is the only menstruum in nature ; or (at least) that, without which there can be none, and with which many other substances being combined, form menstruums which have a powerful operation on many

compound productions, which abound in nature's kingdom.

In the common use of language, the term menstruum, solvent, resolvent, dissolvent, &c. seem to be used synonymously, and are applied to a variety of operations, which, although in some respects they appear to have great affinity, yet, in others are essentially different.

When a lump of clay has absorbed so much water as to settle down in form of paste, or when a stone or any metallic substance is melted by the operation of fire, it is common to say they are dissolved: so also it is said of a lump of salt, when it disappears in water, by solution; and the same of many others—all of which perhaps may be well enough.

But, to say a substance is dissolved, I conceive, strictly implies such a solution and incorporation with an aqueous fluid, as many substances undergo when immersed in liquids—for example: when sea-salt is put into a proper quantity of water, by the superior attraction its particles possess to water, above what they do to each other, it soon disappears and cannot be distinguished from the water into which it has been put; but it is as much salt as it was before the solution,

though its component particles are separated from each other, and when thus divided, are too minute to be discovered by the organs of sight.

But this is but a little part of the process of dissolving a substance: upon tasting the liquor taken from any part of the cistern, the salt is evidently equally distributed to all parts; and notwithstanding the specific gravity of the particles of salt is much greater than that of water, yet as long as all exhalation of the water is prevented, there will be no precipitation of the salt to the bottom, nor will the lower stratum of the liquor be any salter (or, in other words, possess any more particles of salt) than the same space of the upper stratum.

This, at first view, may be somewhat surprising, but a little reflection may cause it to appear plain. The particles of all substances which are capable of perfectly dissolving in water, possess a power of attraction to the particles of water, by which (although their specific gravity may be double to those of water) each one of them attracts to itself, or as near as may be, an equal number of those of water, which number more or less will be in exact proportion to the number of particles of each sort in the mass; consequently, the particles of salt must be perfectly distri-

buted among those of the water, and thereby the specific gravity of every part of the mass be perfectly equal.

But the specific gravity of the whole mass will be greatly increased, as may be seen by putting any thing of proper heft (such as an egg) into a solution of any saline matters, which will rise or fall, according to the quantity of heavy matter dissolved in the liquid.

The uniformity before-mentioned, presents itself to view while contemplating the present subject; for not only all saline and sacharine substances, but parts of almost all animal and vegetable bodies are capable, by decoction, infusion or maceration, (some from their texture and the strong combination of their parts requiring full boiling, others only the warmth requisite for infusion, while others only soaking a time in cold water) of being dissolved and imparted to the aqueous fluid; and by the same attractive power above-mentioned, compose almost an infinite variety of soups, broths, tinctures, decoctions, infusions, &c. &c. useful for food or the restoration of decayed health.

All of which is effected by the mutuality of the attraction existing between the separated particles and those of the liquid in which they are dissolved; for the particles of the

liquid attract those which are dissolved and dispersed among them as powerfully as the dissolved particles do those of the liquid, and the attraction being permanent, the equal distribution will also be permanent, continuing until some more powerful agent shall overcome it.

Among the vast variety of substances which possess the attraction above-mentioned, the operation of sea-salt and saltpetre being much more in úse, come daily to view; from which it appears, that the particles of the juices contained in animal substances, and at least, in many vegetables, are more strongly attractive than those of unconfined liquids; and as the attraction of aqueous particles decreases in proportion to the number of saline particles they have attracted, the attraction of those which have engrossed none must be most powerful; wherefore, they will attract an equal share from the next adjacent, which has drawn a supply; and so, also, the next unsupplied one will attract its share from that.

From a view of which, it is easy to conceive how the salt thus quickly penetrates through a piece of meat, and why so equally distributed.

That the attraction of the particles of the confined juices is stronger than that of those which are unconfined, is evident from this fact, that fresh meat, put into a salt pickle, and frequently changed, will absorb nearly every particle of salt from the brine. How nearly to the same degree of operation this process may be brought, by topical applications, to living animal flesh, is hard to determine, but probably much nearer than at first thought would be conjectured; for, notwithstanding the circulating fluids pass, with great celerity, through the arteries, veins, &c. yet it is evident that there is a portion of the animal juices which have very little motion, (but which are never, for any considerable space of time, entirely stagnant; for though they are not within the coats of the vessels, yet the continual oscillation of the arteries in every part of the flesh, together with the movement of the trunk of the body at every respiration, and the vermicular motion of the intestines, to all of which, with many others, must be added, the motion of the voluntary muscles, dispersed to every part of the body, afford them little time for absolute rest) and in this torpid state may have a greater attraction to the matter topically applied, than to the particles of those contained in the large vessels, in like manner and by the same powers, that the particles in the fresh meat attract more powerfully than

those of the unconfined liquids, (as before explained:) by which wonderful mechanism, remedies, externally applied, are conveyed directly to the diseased parts; which, if internally applied, would, from the indirectness of the course, but slowly and sparingly arrive at the seat of the disorder, and in many cases, never.

If the foregoing hypotheses are correct, is there not a great neglect of topical applications? and is it not a deficiency in the practice of physic which ought to be corrected?

Much proof of the truth of this doctrine seems to be derived from experience. I have heard it many times asserted, by those who had applied to the pit of the stomach, plasters containing oil of mint, that wind, raised from the stomach, exhibited by taste and smell, incontestible evidence of the presence of the particles of mint with it—and the like observations of asafœtida, &c. externally worn.

Which particles of mint, &c. must have passed, not only through the cuticle, skin and muscular flesh, but also, the cavity between them and the membraneous substance which covers the stomach, and through this membraneous substance and the coats of the stomach; or else must have taken a circuit-

ous rout for the purpose of continuing in the fleshy substance, where their passage to the stomach must have been but narrow.

Which plainly shows, that matters so applied are attracted to the inmost recesses of the body, when not obstructed by bony substances, which doubtless, more or less, resist their passage.

May not sea-salt, sal nitre, &c. thus applied, prevent gangrene, if properly used, before it has taken effect? for they cannot restore to soundness that which has become putrid, even in dressed flesh; but may they not, where it has begun, prevent its progress in that which is living?

After much consideration concerning the foregoing proposition, I am unwilling, although it seems quite a digression, to quit the subject without further observations, hoping at least, notwithstanding the newness of the doctrine, to attract the attention of some abler philosopher, to do justice to a subject, from which it is expected much benefit may accrue to mankind.

Had there not been this wise provision in the animal machine, there must have been a great deficiency in the operation of the animal economy. For, notwithstanding the food is masticated and moistened in the mouth, digested and attenuated in the stomach, elaborated and comminuted in the intestines, absorbed by the lacteals, diluted with the lymph in the mesenteric glands, and by the powerful operations of the heart and lungs, arteries, veins, &c. perfectly concocted and prepared to be applied to the accretion (growth) of the body, or supply defects caused by violence or unavoidable wear by the operations of nature, yet the power necessarily required to prepare the aliment as above, renders all the organs employed in that office utterly unfit to apply and assimulate the nutriment to the body, for the purpose above-mentioned; which, before it can be applied, must leave the asterial and veinous systems, and be deposited in a situation where its motion may be much more torpid.

The supposition that a part of the animal fluids are necessarily required to be subject to different states and degrees of motion, from those that are in a state of preparation, to be made fit to be assimulated to the body, seems to require an explanation of the organical structure of the parts by which it is performed; but anatomical description not properly

coming within the design of these inquiries, I shall only observe, that the coats of the arteries and veins are principally composed of longitudinal fibres, supported by transverse ones, and that their coats therefore are not perfectly solid. Hence the particles which are sufficiently comminuted, ground and operated upon, may easily pass through the coats of those vessels, into the spaces betwixt the fibres, composing the fleshy substance of the body; all of which is composed, more or less, of longitudinal fibres that are supported by others placed transversely to them.

It is true the texture of the arteries, veins, membranes, glands, &c. are very differently constructed, but are all capable of receiving the prepared fluids, so transuded.

This structure, so necessary to the growth, activity and continuance of the animal body, like many other things which are productive of the greatest usefulness, is not without a bane; for it is the source of many grievous maladies, the principal of which are scurvy, rickets, gout, atonic rheumatism, &c.

That scurvy is caused by too long continued stagnation of the torpid fluids, evidently appears, from the climate, season of the year, situation and state of inactivity, most

favorable to its production, and the common symptoms of the disease ; and also from the treatment found, by experience, to be most efficatious as a cure.

Experience has abundantly taught, that confinement in winter, in the frozen regions of the north, whether on ship-board, or in huts, has produced the most fatal scorbutic complaints. Nothing is more evident, than the sedative effects of cold ;—rendering the circulation, in the smaller arteries and veins, extremely languid ; benumbing the nerves to such a degree, that the voluntary muscles hardly obey the will ; and, when the degree of cold is excessive, rendering sleep, altho' the victim knows it must terminate in death, irresistable. If, to the severe coldness in the northern regions, confinement, for the space of many months, be added, the torpid fluids must become quite stagnant; the greatest appearance of which will be in those parts where the solids are least operated upon, by the movements of the body, by respiration, the oscillation of the heat, and arteries, the peristaltic motion of the intestines, the motion of the voluntary muscles, &c. And the torpor appears greatest in the small of the leg, (where the muscles have mostly terminated in tendons, which operate but little on the adjacent substance) the instep, the gums, and teguments of the head. But the

erect position of the head, together with the thinness of its covering, and the natural gravitation of the fluids, prevent any considerable stagnation in that part.

It is easy to conceive, that fluids thus stagnated must soon begin to ferment; by which operation, they will become less viscid; which, together with the irritation they produce, by their acrimony, may cause them to be reabsorbed by the vessels, which circulate the general mass of fluids.

But the same cause continuing, they may be again deposited in the same place; which, having, by the first operation, been debilitated, the stagnation may now be continued, till it is attended with some degree of putrefaction. This more powerfully dissolves them, as well as more powerfully irritates the adjacent solids; by which they may be again absorbed, but by which the part is still much more relaxed. Hence, not only the thinner fluids, but the red globules exsude, and the flesh becomes more or less tinged, and appears of tawny yellow, or purple complexion; this is called a scurvy spot. From which, when they have become numerous, and the putrefaction much more, than in the former states, the ichorous matter is absorbed, and being exhaled from the lungs, &c. causes a very offensive breath. This is much

increased by the ulcerous state of the gums, which are, perhaps, from their situation, less guarded against such stagnation, than any other part of the body; and which frequently shows the effects of scurvy, when no other part of the body is affected thereby.

The method of cure is also strongly in proof of the foregoing theory of the source of the disorder, which consists in forcibly rubbing, scarifying, or puncturing the gums, with a sound goose-quill, or otherwise, often repeated; by which operation, the stagnant blood and fluids are forced out of their inactive, spongy substances, which will consequently become firm and sound.

The limphatic vessels, in the white of the eye, which have become turgid with the stagnant red blood that has transuded from the larger vessels into them, being cured by puncturing, and forcing out their stagnant contents, is also an evidence to the same purpose.

But a bad breath is not all the evil that results from an absorption of those vitiated humors. By stimulating the heart and arteries, they cause a hard and full pulse, resembling that which attends a pleurisy or other inflammatory disorder, or that which is pro-

duced by the stimulus of ardent spirits, wine or opium.

In this we have an example of the wise provisions of the animal economy, by which it is ever on the alert, and has power to oppose and expel its most destructive enemies.

Nothing could be much more destructive than the absorption and mixture of such putrescent, death-inducing matter, with the vital fluids; a small quantity of which, like leaven, tends to taint the whole mass, on which the nourishment and support of the whole machine depends, and which, when so mixed, passes with the healthy fluids to the noblest vital organs, which illy support the intrusion of a deadly enemy within their provinces. That powerful exertion of the vital functions, to expel the morbific matter, produces the inflammatory pulse abovementioned. But if the cause continues and increases, and no remedy is applied sufficient to remove it, nature must eventually sink!

The symptoms that mark the progress of the disorder are strong circumstances in proof of the foregoing theory, which the limits of this work will not permit fully to enumerate, but which may be found in many volumes on the practice of physic, which it is requested may be attended to by all who

will take the trouble to investigate the proposed doctrine.

A few of the most prominent symptoms, in addition to those already mentioned, will be noticed; such as general lassitude, dulness, aversion to exercise, sense of heaviness, pain and soreness of the muscles, especially those of the back and thighs, as if over-fatigued, great difficulty in walking up and down hills, the breathing difficult and laborious, so as almost to cease on the least motion, the face of a pale, tawny color; wandering pains of various kinds seize all parts of the body, both internal and external; hemorrhages, but of the slighter kind; all of which are most severe when awaking in the morning. When the disorder is still much more increased, the gums inflame, smell intolerably, bleed and mortify; the teeth loosen, turn yellow, black, and at last, carious: fatal hemorrhages from the external skin, without any wound, and from the mouth, nose, lungs, stomach and other internal parts, are not uncommon; also, ulcers of the most obstinate kind, that will yield to no sort of application, which readily terminate in gangrene in every part of the body, &c.

That the above symptoms are a concatenation of the effects of putrescent matter, re-

ceived into the blood and conveyed to the vital organs, &c. I think will not be disputed.

There have been many instances of those who have unawares, or from want of prudence, been exposed to the exhalations from putrid carcases or other deleterious matters, who have been suddenly debilitated, and in some instances, have quickly died—others, when the destructive effects have been less powerful, have long suffered distressing depravity of the vital and natural functions; but, there being no repetition of the cause, nature has been able to overcome the malady.

Why may not putrescent matter, generated within the body, produce disease, as well as that received from without?

Can there be any doubt concerning the truth of the supposition, that the fluids, fully prepared for assimulation to the body, must, before they can be applied for the purpose of growth or repairs, be secerned into a different system from that in which they are prepared, which must be in every solid part of the body; but that in some parts they are much more liable to the evils of long continued stagnation than in others?

That the effects of the scurvy are in proportion to the coldness of the climate and

season, the sedative operations of which have been concisely considered, it is presumed no one will deny.

The absolute necessity of bodily exercise, to prevent the stagnation of torpid fluids, hardly need be mentioned.

That hard, salted and smoked meat, without vegetables and bread, or with old, wormy, damaged bread, can but with difficulty, in the best climate, with sufficient exercise, support life and continue a good state of health, must be acknowledged; but, when the air that is inspired by the lungs, and with which the body is surrounded, is alone almost sufficient to corrupt the circulating fluids, the disposition to putrefaction must be greatly augmented.

Do not all the foregoing, and also the method of cure, found by experience most successful, plead strongly in favor of the truth of the proposed theory? What is there more likely to produce and continue ulcers, that will yield to no application whatever, than decompounding animal substances, continually received into the vital fluids, and from thence expelled by the vital powers into those ulcers? and may not the same be said of all the other important symptoms of the disorder?

Are not those spontaneous, fatal hemorrhages the effect of mortification, begun in those torpid fluids and communicated to the adjacent substances?

It is true sufficient debility may produce disorders terrible in their appearance and consequences; but such are commonly acute fevers, and not chronical diseases.—And do not those terrible symptoms in scurvy, although almost universal, exhibit the appearance of originating in local situations? for the vital powers hold vigorous almost to the last that suffers.

Again, the most salutary treatment is evidently that which resolves, softens and blunts the corroding power of the stagnant fluids, and at the same time prevents further stagnation—such as exercise in pure warm air or clothing, acid fruits, vegetable diet, &c. which seldom fail speedily to cure the disorder.

The principal cause of the different appearances of the symptoms which attend rickets and scurvy, seems to arise from the different age of the subject, and the very great difference of diet.

The soft, inoffensive milk diet, that supports the tender body of an infant, is opposite

as can be conceived, to the hard, salt and smoked meat, which, with other causes, produce the scurvy in adults.

The tender constitutions of infants are more favorable to the stagnation of torpid fluids than the vigor of adults—so also is the inactive state in which, for the greater part of the time, they remain ; but if care is taken to preserve them from cold and dampness, and if they are properly exercised, no difficulty will arise on that account ; but, when from neglect, or the badness of their constitutions, they are affected with the rickets, in consequence of the recumbent state of the body, so common to them, their heads are as often, perhaps oftener affected than other parts of the body. The most effectual remedy for the rickets is such management as is most powerful to put in motion stagnant fluids ; *i. e.* friction with a flesh brush or the hand ; riding on horseback ; stimulants and tonics ; cold bathing has been recommended, but whether with propriety or not I leave.

The operation of the laws of nature within the animal body (whether for the agreeable and salutary purpose of preparing nutricious matter, to be assimulated to the body, for additional growth or repairs ; or the disagreeable and morbid operations, productive of sickness and death) are dark and intricate,

to the discovery of which our organs cannot penetrate: our information concerning them must be derived only from their known effects and operations in matters more conspicuous, and from the final termination, which sooner or later takes place. By carefully observing the foregoing, and all the concomitant circumstances, and comparing the various events of those obscure operations with the events of those which are more conspicuous, we may arrive at a tolerable degree of certainty, concerning the cause and manner of their production.

Are the different appearances of scurvy and rickets, or the symptoms which attend the two disorders, more various than in reason we ought to expect, with no other cause to produce them than the difference of constitution, aliment and temperature of air or clothing? Is it a hard matter to conceive that the nutriment obtained by the operations of the natural functions, from hard, salted and smoked meat alone, (which can but partially be digested, in the most favorable circumstances) must be essentially different from that obtained from the soft and tender aliment (consisting of milk, &c.) by which infants are supported?

Will not the former, in spite of the powers of the animal and vital functions, have an

irresistable tendency to putrefy, by the shortest stagnation; while the latter, almost free from all tendency to putrefaction, may be secerned into a situation for torpid movement, and for a long time remain almost stagnant, without any other injury than a morbid, supernatural assimulation of the same to the softer parts of the tender bones of infants, in which the torpor must be greater than in the flesh—such as the epiphyses of the larger bones, the sternum, (or breast bone) the cartilaginous ends of the ribs, and some parts of the spine of the back, may for some reason, though not altogether obvious, be liable to the same assimulation by which preternatural growth and distortion are produced; which, when properly condensed, and health is generally restored to the body, prove not greatly injurious.

Gouty complaints seem generally to be the effect of excessive indulgence in the use of ardent spirits or wine, together with neglect of exercise; for those who constantly follow hard labor, and have also good constitutions, endure the most extravagant use of spirits for many years. But there are other debilitating powers that produce gout; yet there are few instances of its attacking those who do not add to other causes, (be they what they may) the want of exercise.

The indirect debility occasioned by the excessive stimulus of high living, attended with inactivity, is altogether favorable to a stagnation of those fluids in the torpid state before considered. And the remedy, many years ago much approved, for the cure of the gout, (by tonics, such as bitters used in extraordinary quantities) proves clearly that debility, or inactivity of the fluids, is the cause of the disorder. But the final effect of that remedy also proved, that the excessive stimulus of the bitters, although it gave temporary relief, yet, before many years had elapsed, produced a more destructive debility, which terminated life, by inducing asthma, dropsy, or some other fatal malady.

Atonic (or chronic) rheumatism, strictly such, it is believed, differs from gout only in certain circumstancial matters; such as the natural constitution, or the peculiar debilitating powers; for certain things that cause debility, may operate more powerfully on some parts of the system than on others. Hence, although the effect is debility, it may cause some variety in the appearance of the disorder, dependent on debility; for, according to the definitions and descriptions of the best writers on diseases, it is not easy to decide which of the two last mentioned disorders afflicts the patient, unless his *standing* in society is known to the physician. If he is a

gentleman, it may be gout; if not, it must be styled no higher than—rheumatism! It is therefore believed, the same cause produces both complaints.

As to the method of cure, as common, when the cause of the malady is obscure, the treatment recommended by the best medical writers, is vague, various, and sometimes clashing; or, in some instances, it is agreed, that it is doubtful, whether any remedy is yet discov red. Gout and chronic rheumatism seem to come within the last mentioned.

Facts are worthy attention. I was once requested, by one who had a violent affection of the ancle-joint, of the kind above mentioned, to open a vein, upon condition the orifice should be large, and he direct when the ligature should be removed; to which I readily agreed. His foot bled freely, he sitting in his chair, till faintness compelled him to lie down upon the floor; where he continued to bleed, until he became so faint, as to make it necessary to call for a bottle of bitters, of which he often drank; but oppression at his vitals, after repeated admonitions to desist, caused him to direct the removal of the ligature, after bleeding probably a gallon; it might be much less; but bleeding in a cistern of warm water, prevented ascertaining the quantity—the consequence of which was

a complete cure, although the disorder had been of long standing.

He was about thirty-five years of age; of a firm, robust and hale constitution. The complaint, as I judged, was occasioned by a debility often brought on by a certain error, not uncommon to those of such constitutions, but which, to the slender, is much more frequently obnoxious—he was at least so much of a christian as to love women and hate snakes! add to this the most persevering attention to hard labor. Had he been of a slender constitution, such an excessive evacuation would probably have caused an atrophy, dropsy or some other malady, which, after some months lingering, it is most likely, would have terminated in death.

One, although in health, who lies in bed much beyond his usual hours, finds, when he rises, the muscular parts of his body stiff and sore; the cause of which, it seems, must be the stagnation and accumulation of those fluids which are out of the circulation of the arteries and veins; for the circulation in those vessels is more vigorous when sleeping, than when awake.

It is observable also, that those who are easy and inactive, but use exercise sufficient to prevent diseases, with indifferent living

become corpulent; while those who are constantly active, with high living, are spare of flesh. Are not these last clearly accounted for by the foregoing theory?

There seems no doubt but the cause of many other disorders, than those before-mentioned, may be traced to the same source.

But it is hoped enough has been said to call the attention of those who are more competent to investigate the subject.

Fire (as before observed) is the essence of heat; and without it, there is no heat or warmth. Whether exhibited by friction, the laws of the animal economy, fermentation, putrefaction, or directly from the sun, the essence is the same.

The sun is the source of heat, from whence alone, it is derived, notwithstanding it should, at creation, have been used as a component part of some huge rock, or any other compound substance, as yet but partially decayed, but whose component parts must, in time, return to their primogenial state, when it must proceed to its centre, the sun; for it

has been before observed, the works of creation were at first perfected.

The corpuscles or rays, which proceed from the sun, are both heat and light; and whatever different effects they may have on our organs, still they are one and the same essence. Whether called caloric, principle of heat, latent heat, fixed heat, matter of heat, materia solis, (or matter of the sun) it is that of which the sun is solely composed, and which is neither increased nor diminished; for not being a compound substance or subject of growth, it is not a subject of decay: but by the immutable power, which the great body of the sun possesses from a law of nature, it projects an uninterrupted shower of its rays to regions of unknown distance. A ray of the sun, thus repelled from its source and centre, passes by or comes against the earth, the moon, a planet, or star, with total indifference; suffering neither attraction nor repulsion, to or from any body whatever, in its passage, except its great source the sun. Nor has the common gravitation of the earth the least power upon it, for it is without ponderosity.

But by another law that the sun possesses, (which though less powerful, is still more extensive than that of repulsion) whose constant attraction must, in time, overcome the egress

of the ray ; after which it must retrograde or descend towards the sun, its centre. And as the velocity of gravitating bodies increase in proportion as they approach their centre, the returning ray, by the power of attraction, with the additional power of motion which it has acquired, will be able to arrive at its centre, against the otherwise superior power of the law of repulsion. By this wise provision, not a single ray of the sun is ever lost in unbounded space.

If the foregoing hypothesis is not admitted, a better should be found ; for there can be no doubt but that the sun, by such incessant emission of its substance, in every direction, must before this time, have been greatly diminished, if no provision had been made for its return to its source. Nor is the constant dissipation and waste of such vast quantity of rays, in unbounded space, agreeable to the economy of nature. Again, we read when the work of creation was finished, Infinite Wisdom pronounced it all very good ; if perfectly right, (which is the same thing) an alteration must make it wrong. And if the works of the Creator are subject to decay, it was necessary to have created the sun much larger at first than was useful, that at a medium of its existence it should be right ; for, by that provision, the imperfection must be equally divided ; (i. e.

it would be as much too big the first half of its existence, as too small the last) which is equally contradictory to scripture, sense and reason.

Nor does this hypothesis afford an argument against the opinion, that fire is an element; for, if the works of nature were completed at creation, the subsequent accretion of all compound substances must be in exact proportion to their decay and decomposition; so that there must be as much of the materia solis evolved and set at liberty, as involved and thereby confined.

If it should be said, that the corpuscles of fire, thus set at liberty, must obey the stronger power of repulsion, and, instead of being returned to the sun, would thereby be driven into boundless space—I answer, the more extensive law of attraction will not there fail to find them out, and return them to their source, at least as readily, (for being once stopped in their egress, they will not be repelled to such a distance) as those which have been driven the utmost extent the power of repulsion could send them.

When, among the learned, the greatest characters and first philosophers differ, concerning a question of importance, each party setting up and supporting a mode or system

of their own, and condemning that of the others, it is next to demonstration, that neither is right; for that which is not wrong may be made to appear right, to those who have abilities to discern, and powers to investigate.

This has been the case concerning fire; among the first characters, one party having adopted the foregoing hypotheses, so far as to admit fire to be a material entity, and that it is diffused through all space; and further, they assert, that it penetrates all bodies, and that it has a repelling power, by which it enlarges the volume of all.

That fire composes a part of most, if not all compound substances, is not denied.—That anticrouon (the repeller, or principle of repulsion) is, in a greater or less degree, possessed by the corpuscles composing all substances, whether solid or fluid, cannot be denied; and that, in all instances, the anticrouon is excited to a more powerful and extended operation, by the power of caloric, is equally true.

And, because the operation of fire never fails to excite the principle of repulsion to a greater exertion, it has erroneously been considered as the essence of repulsion, and that fire and anticrouon are one and the same thing.

But, that they are independent of each other, appears many ways. There are many substances which possess anticrouon (or the repelling power) sufficiently to cause them to be perfectly fluid, when destitute of all caloric, and possessing the greatest abundance of cold. Even water retains its fluidity when containing much of the matter of cold, and no particles of fire. Air, which is the most perfect fluid, excepting fire and electrical fluid, sustains no sensible loss of the repulsion of its particles, in the coldest regions. Rectified spirits retain the power of repulsion, without any sensible diminution of their fluidity, in the coldest weather. But that is not all ; there are other matters besides fire which increase the power of repulsion, existing in many things. The anticrouon of the particles of water is excited by wind, to a degree sufficient to produce exhalation, even when congealed by the matter of cold, to ice : and many others could be mentioned.

If anticrouon and caloric (or the principle of repulsion and the principle of heat) are one and the same thing, all bodies must be hot, in proportion to their rarety ; (for rarety depends upon repulsion, to keep the particles asunder) therefore, that which is most rare must possess most of the principle of heat, and air being the rarest of all bodies,

must be the hottest in the world.—But it appears to be the very magazine of cold; nor to possess the least degree of heat but what is communicated to it, and has little power to retain what it receives.

Furthermore, fire is the most transient substance which comes to our world; no place ever possessing the same degree for any length of time: therefore, of all things, it is the most unfit to cause and continue the fluidity of air; without which our lives must instantly cease, and with any considerable variation of which, health must, more or less, quickly decay.

As treatises on natural philosophy are not in the hands of every one, I take the liberty to transcribe, from a late edition of Quincy's Lexicon Physico Medicum Improved, under the word caloric, the following lines, being a compendium of the idea of fire, which appears at present to be generally adopted.

" Disputes have been entertained whether caloric was itself a substance or material being, or whether it was but a modification of other substances. Hence arose two doctrines concerning it: 1st. The mechanical doctrine of fire or caloric, which taught that it consisted in a subtle, intense and vibratory motion among the intestine particles of bod-

ies, as the heat excited by the friction of a wheel against its axle-tree, of the mill stones upon the grain crushed between them, of an iron rod hammered upon an anvil, of an iron cannon suffering the operation of boring under water, &c. where much caloric is evolved by mere agitation or percussion, without derivation ab extra, or communication from any heated substance. 2nd. The chemical doctrine of fire, affirming that it is a most attenuated and penetrating fluid, travelling thro' all space and nature, insinuating itself into the pores and interstices of every species of bodies, producing repulsion and enlargement of volume wherever it goes. No attempts hitherto made have been able to prove its ponderosity or materiality. It cannot be weighed in the balance. Its addition augments not sensibly the gravity of bodies; nor does its subtraction lessen their weight. In many cases, too, there is an impossibility of explaining whence the caloric present in certain bodies is derived. These considerations have led some of the most discerning of modern philosophers to doubt, or even to deny the materiality of caloric; and some of them profess to believe it is a non-entity. To these, caloric must appear only a repelling power, inherent in the atoms of matter, and susceptible of increase and diminution. And in this sense, which is probably the true

one, caloric or anticrouon is but the counterpart of attraction," &c.

Its minuteness and transientness, together with its total insubjection to the laws by which all other matter is governed, renders all chemical attempts to explain the essence and mode of operation of fire perfectly useless: art has no power to confine it; for although some substances can retard and reflect it, yet no created substance can finally resist its penetrating power. And, notwithstanding the laws of nature have power to involve it with other substances, and with them apply it to form and increase the accretion (or growth) of compound bodies, thereby retaining it in confinement for a time; yet, it finally bids defiance to their power, and taking leave, departs to its great and more powerful centre. And when, from this natural but partial confinement, it is removed by the chymist, for the purpose of inspection and investigation, it imperceptibly withdraws from his power, and all his hopes and expectations vanish.

All are agreed that "it cannot be weighed in the balance," and it is said that "it augments not sensibly the gravity of bodies; nor does its subtraction lessen their weight." There must be some error concerning this last, which has probably been the result of

haste, or the want of sufficient attention in observing; for its addition, in all cases, enlarges the volume of bodies, by which they must become specifically lighter, in proportion as they are increased by that which has no ponderosity, which in this case, could without doubt, by careful observation, be perceived. Although the chymist cannot analyze fire, it being more transient than the water which turns the wheel, yet he may, by his art, turn it to great account—for it is the principal agent by which he can open to view almost every other existence, and thereby investigate the mysterious arcana of nature. But all that has been said, affords no argument against the existence of fire. The vast importance of fire in creation; (without which no animal being could exist alive; neither could there be vegetable, mineral or fossil production) and the great pleasure the animal creation collectively enjoy from the agreeable sensation of warmth, as well as innumerable other ways in which it promotes their happiness, one would think are sufficient to entitle it to an acknowledgment of its existence.

Nor can I subscribe to the doctrine that the rays of the sun are not heat or fire until they are reflected, and that the heat then produced is the effect of the friction between the projected and reflected rays: this error seems

to have been produced by observing the effect of friction. Two pieces of timber, rubbed powerfully together, produce heat; and if the friction is continued with sufficient power, light and fire are perceptible: so also of the flint and steel, as well as many other substances. Hence the idea that fire is only matter in motion, produced by attrition; and when communicated to combustible materials or fuel, unless counteracted by the aqueous fluid of the fuel, or resisted by some external application, the vehement agitation or motion will continue until the whole is consumed. It is not a little surprising that any one should suppose that fire is not an essence of its own kind, even admitting that friction produces heat, that there should be friction enough, by the attrition of the sun's rays, to produce that effect; for fire is a fluid, and possessed at least of the essential quality to constitute fluidity, viz.—a repellant power, which prevents two particles from ever touching each other.

Taking into consideration the great variety of evidences, which, unsought, are continually crowding themselves into view, in proof of the proposition that the sun is the source of fire, it seems hardly necessary to make use of any arguments further to elucidate and substantiate the matter. But as many philosophers, who are entitled to dis-

tinguished respect, have been of a different opinion, it may be well, at least, to examine the validity of the proof. The most striking evidence is, its coming directly from the sun. If there is no deception in the matter and we can believe our own senses, this alone seems conclusive evidence of the fact —for who has not often, when chilled with cold, by removing into a situation where the sun's rays could be received without obstruction, experienced the most agreeable warmth, which could be ascribed to no other source?—and who has not also, when oppressed to faintness by heat, (which no one will deny to be the effect of fire) been revived, and experienced the greatest pleasure, by a relief from heat, in shunning the power of the sun's rays? are not these demonstrations? or are our senses to be doubted, as unworthy our confidence? if so, let us have recourse to brute animals for proof; for the most stupid of them have sense enough to retire from the operation of the rays of the sun when oppressed by heat, and to seek an agreeable warmth from the same when pinched with cold.

But the power of the sun's rays may be made to operate and appear in a more powerful and striking manner, producing, when collected into a focus, by a proper lens, the most vehement and intense fire, within the

power of art to kindle. And the matter of the sun, which can thus melt stones and turn earth to a green glass, comes directly and in a straight line from the sun ; for the lens must be placed in a position thus to receive them. That the rays of the sun pass in straight lines, is further proved by eclipses and transits of planets on the sun's disk.— These observations are considered sufficient.

The only question remaining, is, whether there is another source of fire belonging to this world ? which question may perhaps be satisfactorily answered, in considering whether fire is an element.

Notwithstanding electrical fluid much resembles the matter of the sun in some respects, yet an attempt will be made to show that it is a materia per se, having no connection with, or dependence upon the sun or its rays.

Many of the arguments which are evidence that the sun is the source of fire, are also evidence in favor of the supposition, that fire and light are one and the same essence.— That the sun is the source of light, is as evident as that it is the source of fire ; indeed, I know not that it is denied by any one ; and if it is admitted that the sun is the source of

light as well as fire, it will be hard to prove that they are not both one.

Do not our senses prove to us that the same essence operates on the organs of sight and the sense of feeling ?—for at all times, when there is nothing to obstruct, by turning our eyes toward the sun, they are instantly irritated by the rays which are projected from it—we also, at the same time, feel the warming operation of the same rays, in our bodies. If both are not produced by the same rays, there must be two kinds sent from the sun ; and is it not too absurd to suppose there are two kinds sent, when one can as well answer both purposes ?

We find three of our senses (tasting, smelling and feeling) operated upon by innumerable things : the sense of hearing by one only, *i. e.* the medium of the atmosphere.

There can be no reason (but only that we have not been accustomed so to believe) why we should be surprised at the supposition, that there are two substances which operate on the organs of sight, (viz. materia solis and electrical fluid.) Those substances,

which are too minute and transient for inspection and observation, can be judged of only by their operations and effects collectively, and the various operations and powers the different laws of nature have upon them.

There appears to be no doubt but there is some difference in the form or some other of the properties belonging to those substances, on which the laws of nature have different operations; for those things which have identity of essence must be subject to like powers of the laws of nature. But the common rays of light (*i.e.* matter of the sun) seem to be subject, principally and almost entirely, to the power of their own centre—entirely as to gravitation: but when in their nearest approach to other matters, they seem to repel and be repelled by nearly all substances, whereby they are moved in every direction; sufficiently collected however, to communicate the image of objects, through the eye, to the mind, unless they have penetrated so far among the component particles of compound bodies, as to rebound from one particle of the composition to another, so as to be as ready to pass through or return another way, as the way at which they entered; in which state, although they never rest, they may be retained for a time—or by some law, to us unknown, are involved with other matters, in the growth of compound substances,

where they suffer entire rest until evolved and set at liberty; and excepting that mysterious law by which they are confined in compound substances, at the time of their growth, they seem to be subject to none of the laws of matter in the world, but that of absolute resistance or repulsion, by which they rebound or are reflected as before stated.

That they are not subject to the laws of gravitation, fully appears from this, that if they were under the least control of that law, instead of passing in straight lines, when moving in directions horizontal to the earth's surface, they would move in curved lines—for although they move from one object to another with inconceivable velocity, yet, if they are in the least within the power of gravitation, their lines of passage must be curved, probably as much as the surface of the earth; by which operation we could see over mountains; or if the curve was the same as the earth's surface, we could view our antipodes.

The number of rays necessary to answer the purpose of vision are comparatively very few, to what are sufficient to produce an intense fire; for if in the shade, in the light of day, one is placed before a looking glass, the rays which are reflected from the face to the glass, and from thence again reflected, are sufficient to exhibit the image of the face to

millions of eyes, if so many could be in a situation to receive them.

We are taught by Sir Isaac Newton, that colors exist only in the rays of light; hence Mr. Martin seems almost to ridicule the idea that they can be distinguished by the sense of feeling. But Dr. Bœrhaave informs us of one who was born blind, who could distinguish colors with his fingers. Nor is there any mystery in this: what Sir Isaac says, is undoubtedly true; and that which Bœrhaave asserts, is probable enough.

Color is the different appearance with which external objects strike our eyes:—without light no object can affect the eye; and experiment has fully proved that the different shades may be produced, by only refracting or turning the rays of light in their course; therefore colors exist in the light only. But there must be something different in the surfaces of the objects, which reflect the rays of light so as to produce the different ideas of color; which may be produced, by incorporating certain matters (called dye-stuffs) into the substance of the cloth, by art, by which the surface of the cloth may be so altered as to be distinguishable by the nice feeling of one unused to seeing; who, having been taught what colors were represented, by such and such deas of the

sense of feeling, experienced by him, could pronounce the name of the color, as it appeared to those who could see it; yet was as ignorant of its appearance to them, as another who was born blind, who after hearing the most ingenious description, by words, supposed he had acquired a perfect idea of the color red, and being asked how it looked, answered, it exactly resembled the beat of a drum!

Such incorporations of substance, with cloth, &c. produce almost an infinity of shades: but that which is dark or black, said to be no color, and white, which is said to be all colors united, are most remarkable.

Cloth that is dark, is not perfectly so, for it reflects rays enough to be discernible by the eye; but the incorporated matter enables it to absorb or receive into its substance, almost all the particles of light which come to its surface—which are accumulated in it to such a degree, as to cause it, when spread upon the snow, where the sun shines, to melt the snow in such a manner as to settle some depth into it; when that which is white will remain without any impression on the snow.

The rays, thus received into the substance of the cloth, operate in a manner similar to those which are communicated from an arti-

ficial fire, to iron, or any other solid substance; which, having once entered among the particles, bound and rebound from one to another; by which means they are for sometime detained, but gradually (and not in regular eradiate lines, nor with the same velocity as when reflected) emerge in every direction, and are not sent out at any point, in sufficient quantity or velocity, to operate distinctly on the eye; but moving slowly from the iron, are accumulated in such quantities around and near about it, as to cause a more or less powerful impression of heat upon the hand held near it. The particles of fire, in like manner emerging from the cloth, have no effect upon the eye; for the mode of their issuing in irregular, uneradiated directions, admits not, perhaps, of two moving from the same point, in the same direction, and at the same time; the few rays by which it is seen, being reflected instantaneously when striking it, not having entered the substance of the cloth at all; and being few in number, the mind is struck with the idea of an opaque or dark substance.

Hence iron of the above heat is said to be dark hot; but when the accumulation of fire in the iron is so great as to be emitted in sufficient showers and velocity to operate on the eye, it is said to be red hot; and when

the quantity is so great as to glow almost with blaze, it is denominated a white heat.

In the above, we have an example of the production of a very considerable degree of heat, by fire, without the sensible appearance of light.

That the dark hot iron is heated by the reception of that which operates as light to the eye, is evident from this—that the same iron which appears of a black heat, in the light of the sun, (when the eye is contracted, that it may not be injured by receiving too powerful a shower of the rays of the sun) will appear of a red heat, and shine with a glowing light for a distance round, when removed into a place where all light but its own is excluded, (when the sight of the eye will dilate, that it may have vision with fewer rays, or in other words, that it may catch more of the scattering rays, which it has a faculty of converging into a focus) on which powers of contraction and dilation of the eye, the greater or less perfection of vision depends.

And if our organs of sight were so perfect, that one or a very few rays were sufficient to communicate to the eye the impression of objects, we should discover a red appearance in the iron, as soon as perceive the warmth by feeling. Hence it seems that it is not the

want of light, in the dark hot iron, which prevents our seeing it, when the heat is almost exhausted, but the imperfection of our organs.

From what has been said, it is plain, that black clothes, worn where the sun or fire shines, will cause the body to be warmer than those which are white.

That which is said to be a compound of all colors, termed white, is diametrically opposite to black or dark. That it is a compound of the seven original or perfect colors, is generally thought to be proved by mixing seven equal portions of the finest powdered substances, each one answering exactly to one of the seven original colors; which, when intimately mixed, by rubbing in a mortar, compose a most beautiful white, or light appearance, and reflect all the rays of light, or perhaps as nearly all as the black absorbs all. That they absorb some, is evident; for they may be made slowly to receive enough to make the substance feel warm.—But they so powerfully repel the rays of heat, that the focus collected by a small burning lens, can make no impression on paper that is of a pure white; yet, when stained with ink or other dark matter, the same paper will instantly take fire. Hence the propriety of wearing

white, to avoid excessive heat from the sun's rays or other sources.

It appeared necessary thus far to enquire into the operations and effects of light—its connection and dependencies, and also its independence of, and subjection to the laws of nature ; whereby we shall be the better prepared to decide, whether the matter of the sun (or common light) and electrical fluid are both one, or not. But previous to determining the question, it is requisite also, so far as discoveries will enable us, to examine concerning the essence, operations and dependencies of electrical fluid. After having considered the whole matter, it is hoped the decision may be correct.

Whether electrical fluid makes a part of any of the compound productions of the laws of nature, (*i.e.* whether it is an element or not) is uncertain : but the succeeding facts seem to prove beyond doubt, that it is a primogenial, uncompounded substance—that its corpuscles are vastly finer than those of the sun—that it is diffused among the particles of all compound substances—that it is evidently subject to the law of gravitation, and to the attraction of several matters, at least under certain operations : and it appears to be powerfully repelled by some substances, but most of all by air.

Its attraction to metalic and animal substances and water, seems to be nearly equal; hence metals and water mixed are thought to attract more powerfully than when alone.

Its usefulness may be much greater than has yet been discovered. There is no doubt of its salutary effects, when properly applied, in some diseases. It is much to be wished that further experiments were scientifically performed; which may be done without the least injury to the patient.

That the corpuscles of electrical fluid are much finer than those of the materia solis, is evident from its so suddenly penetrating solid substances, and passing in them with the greatest velocity, and that without any obstruction by their density: such as the most of animal and vegetable substances, and perhaps all metals.

Its progress is so rapid in iron or steel, although the distance be considerable, as not to be perceived by our senses Nor does it pass on the surface, but in the substance of the iron; for in the darkest night, let the distance be what it may, so far as the wire is unbroken, it cannot be discerned; but if the wire is formed into a chain, it appears crinkling like lightning, and suddenly disappears. Hence, it evidently passes in the substance,

without being in the least obstructed in its passage. So easily does it pass in the substance of iron, that the greatest charge which is exploded from the clouds, may pass in an iron conductor of sufficient size, though it is driven through a log of wood fifty feet in length, compressing the rod never so closely, without the least injury to, or operation upon the wood; whereas the matter of the sun enters the substance of iron but slowly, rebounds among its particles for a time, and is dissipated in air insensibly, excepting for a time whilst emerging, it communicates the sensation of warmth or heat to the part applied to or near it. In all the above particles, the matter of the sun and electrical fluid differ materially.

That it is diffused through all compound substances, and probably all solids which contain an aqueous fluid, appears from its being attracted by the friction of certain substances, such as leather covered with chalk or amalgama, &c. rubbed on glass.

Let the machine be placed where it may, provided it can communicate with the earth not perfectly dry; and the communication may be by the floor of the house to the cells and underpinning, none of which may be utterly free from aqueous moisture; for animal and vegetable substances which are en-

tirely destitute of moisture are electrics, and refuse it a passage.

But if the machine is insulated by standing upon glass, rosin, bees-wax, dried animal substances, baked wood, &c. and the person operating, and all things which come in contact with the machine are also insulated, no electrical fluid can be collected, let the friction be ever so powerful: yet, when the passage is such as suits its movement, there is no part of the earth from which it may not be attracted; though it is uncertain from what distance, but probably from some miles—be that as it may, there is no doubt it may be moved many miles; for nature seems not more to abhor a vacuum than an unbalanced state, between electrical fluid and other matters; therefore, if the just proportion is attracted away but for a few rods around the machine, the balance is thereby broken, and it must rush from all places where it is, to supply the deficiency in that, and restore that equal distribution in which nature so much delights.

Although electrical fluid passes with the velocity of lightning, it is not meant that the same identical matter which moves from miles towards the machine, comes to it, but that it operates as air does in a large room, when the outer door begins to open, the in-

ner door, twenty feet from it, clatters against its casing; which is not caused by the air from without, coming to the inner door, but the first movement of the air without, moves the volume of air within the room in a body, which, at its first movement, presses the inner door against the casing.

So the electrical fluid, being in the least degree drawn from any place or substance in nature, is instantly supplied by the next place or substance, which is also in like manner supplied, and so on of the next, &c. And from its irresistible propensity to supply all places which have suffered any privation of it, the supposition of its general diffusion (as before stated) seems to be fully substantiated.

Its inconceivable velocity also renders such diffusion not only easy, but in some degree unavoidable.

It is believed, that if a chain one thousand miles in length, were attached at one end to the outside of a receiver, the middle moved five hundred miles distant, the chain touching in no point laterally, and supported by electric substances, in an air free from aqueous exhalations, the other end being applied to a charged receiver to admit the electrical fluid, that it would return to the negatively

charged outside of the receiver, after its tour of one thousand miles, without discoverable loss, and possibly without discoverable variation of time between its exit and return.—But the materia solis can be forced but a small distance from the part by which it is received into the substance of iron. In this it also appears they differ widely.

That electrical fluid is subject to the laws of gravitation, appears many ways, but is probably much less so than air; for air, although much the heaviest, can have no power to force it upwards, its corpuscles being too minute for those of air to act upon, the spaces between them being sufficiently large for the electrical corpuscles to pass freely, in any direction, among them; as appears by its serving as the medium of sight; in performing which, the electrical corpuscles pass singly among those of air, as freely as the rays of the sun; but which, when collected, as in an explosion from the clouds, or an electrical spark from a charged receiver, never fail of producing a report by breaking the air.

Its ascent is, in all cases, the effect of repulsion or attraction of some substance to which it is attached, or near; such as the corpuscles of its own kind, which powerfully repel each other, and when collected in a

receiver, are repelled to the end of the spear, which projects through the hermetic ceiling on the receiver, where they appear in form of a small pencil, (hence this appearance is called a pencil) from which they are repelled singly through the air, and communicate distinct vision to the eye.

And although their inconceivable velocity gives them little time to gravitate, yet without hesitation, I hazard an opinion, that when passing horizontally to the earth's surface, they proceed in curved lines, which I have no doubt could be ascertained by an experiment, which, if it so proved, would furnish an art by which we could, more or less, see over obstacles that prevent the passage of the rays of the sun.

By such repulsion, and also by rebounding from object to object, the electrical particles are projected as well upwards as in all other directions.

Although the air repels collections of electrical corpuscles, yet when it is much charged with watery exhalations, it becomes almost as perfect a conductor for the smaller collection, or single corpuscles, as an iron rod ; which is evident from its being impossible to retain it in a receiver, when the air becomes moist. When an electric ma-

chine is operating well, and the receiver retains the fluid without difficulty, the whole matter may be charged by the exhalations from the lungs, &c. of a number of people coming into the room ; by which exhalation the air is made so humid and consequently so readily transports the electrical matter, that it cannot be retained.

Hence it is evident, that exhaled particles of water attract the electrical corpuscles, by which means they are by them carried into clouds : and experience proves that cold weather, when the air is drier than in summer, is much more favorable for the collection of electrical fluid, than warm weather, when the exhalations are more abundantly rising into clouds.

The consequence of which is, that thunder and lightning must be more common in summer than in winter ; for the particles of electrical fluid, thus carried by those of the water, are (by the same power of attraction) by them retained, until, by being condensed, the particles of water gradually distil in form of rain.

But the attraction of the greater quantity which remains behind, being superior to that of the falling drops, the electrical fluid will also continue back with the clouds ; yet, lo-

sing part of its supporting matter, it becomes more collected, whereby the repulsion of the air towards it is increased ; and the exhaled particles of water (by whose attraction it is supported in the air against the power of gravitation) diminishing as the rain falls, not only the balance between the electrical fluid in the earth and that in the clouds becomes unequal, but between one volume of cloud and another. And notwithstanding the corpuscles of electrical matter, when near together, repel each other, yet, at a distance, it is evident they attract each other powerfully ; wherefore the electrical matter, suspended as aforesaid, is powerfully attracted by that of its own kind in the earth, in addition to its gravity. And these powerful agents are opposed only by the attraction of the now much exhausted watery exhalations or clouds, and the resistance of that powerful repulsion existing between electrical fluid and air, which forbids a passage to the fluid without a force sufficiently powerful to open and repel all air entirely out of its passage; by which breach in the air, the tremendous report of thunder is produced.

The clouds becoming still more exhausted by the precipitation of the rain to the earth, the overcharge of electrical matter is so great, that notwithstanding the repulsion of the air towards it, it breaks from the now

too feeble attraction of the exhalations of watery particles, and takes its departure to the earth, to restore the broken equilibrium in nature with an explosion which spreads dismay among the inhabitants of the world beneath, and seems to threaten general destruction!

But, if another collection of cloud is much nearer than the earth, which is not so highly charged with electrical fluid, the attraction of that cloud may be superior to that of the earth, and the explosion be to that cloud, and it may possibly be again exploded to another, but must eventually, in some manner, come to the earth.

Having (perhaps superficially) considered the operations of the laws of nature by which the matter of the sun and electrical fluid are governed, we find each of them possesed of properties of great importance; yet we discover no properties common to them both; but that they are so widely different, that no person will presume to contend they are both one: the only particular in which they seem in any measure to agree, is, that they both serve as a medium of sight. And in this

they but imperfectly agree; for there is no evidence that electrical fluid ever has that power, except when by some operation of the laws of nature, or by art, it is accumulated to a degree quite uncommon; in which case alone, it operates as light to the eye; and mostly so when it breaks from confinement by explosion, which appears strikingly bright, and seems to illuminate the whole hemisphere, when it is discharged from the clouds in a dark night.

The operations of the laws of nature, by which the mind annexes to objects the ideas of color, figure, (or form) extension, &c. by the medium of the rays of light, through the organ of the eye, are not a little mysterious; but close reflection and reasoning may possibly cast some light upon the subject.

We are so often told that the image of objects is painted on the eye, that the phrase has become familiar; but it is hard to conceive how an image or shadow in the eye can effect the mind in such a manner as we experience.

The process seems to be as follows: that exquisitely sensible organ, the eye, is susceptible of the stroke or touch of a much less number of the very fine rays of light, than any of the other organs of sense, on three of

which, in their peculiar capacities, (as light) they have no operation; yet, when much increased above what is necessary to affect the eye, they produce the sensation of warmth on all the organs of sense.

The only operation it has on the eye, is a sensation from the impulse, or a kind of feeling which the eye suffers from its irritation or stimulus, and the innumerable different operations on, or ideas received by the mind; *i.e* the vast variety of shades with which the mind is impressed, from the eyes' receiving the rays of light, are not the effects of the images or colors being painted on the retina of the eye; but solely depend on the aforesaid impulse or stimulus. To every degree of which, the mind annexes the idea of a different shade or color; *i.e.* to the lowest degree of sensation or stimulus, capable of exciting in the mind the idea of color, it annexes the idea of a certain color or shade, and to every degree of irritation, by the rays of light, capable of producing in the mind a different sensation, by their impulse on the eye, the mind annexes the idea of a different shade.

But the operation of light on the eye is capable of producing but seven degrees of distinct irritation; therefore, there are but seven distinct, or uncompounded colors.

It is not to be supposed that the excitability of the eye, upon which the rays of light operate, is gauged to seven distinct and unconnected degrees, as seven of them, of certain and equal distances, may be marked on a rule; but that the excitement is increased in exact proportion with the velocity of the rays received; and from a medium of one degree to the medium of another, including the opposite half of each, makes two, which operate distinctly on the mind; of which mediums of distinct excitement, there are seven; therefore the mind has distinct ideas of seven colors only.

But if the velocity of the rays is such as to produce a stimulus between the medium of the first and second, the mind will then be impressed with the idea of a shade between the first and second primary or distinct colors; which shade must be a compound of the first and second; and in the same manner, any variation from the degree of excitement, which produced that idea of shade, may produce the idea of another, &c. by which they may become innumerable.

And this doctrine agrees exactly with the effects of an experiment of Sir Isaac Newton, (which it must be acknowledged gave rise to the opinion that there are seven distinct colors only) in which the distinction is the

effect of (or the seven colors were produced by) refracting the rays of light.

But how, only turning the rays in their course to the eye, without in some other manner, affecting the power of their operation, can communicate to the mind, an idea of a different color than that which the same rays would have done, if they had not been turned, is not to be conceived. But the fact seems to be, that the rays which are turned in their course, meet with a resistance from the substance that turns them, by which they are retarded in their velocity, and the momentum with which they strike the eye is diminished; wherefore, the eye must feel a proportionably less operation than from those which are less refracted: hence the mind must receive or form ideas of different colors.

That there are seven distinct colors only, appears, not merely by Sir Isaac's experiment, but by the refraction of the rays of the sun in falling drops of rain; in which there is the appearance of a bow, exhibiting the same seven colors distinctly. So also, they appear in ice that is cracked, or by the rays of light passing through a prism formed of glass, &c.

It seems clearly not to be alone the refraction or turning the rays of light in their course which causes the different ideas of color in the mind, but the effect of the refraction; *i.e.* retarding them in their movement, by the resistance of the substance against which they are turned, whereby their impulse against the eye is diminished; which diminution must be increased, accordingly as the rays are more refracted, and the irritation of the eye must be diminished in proportion; the least degree of which, that is capable of exciting the idea of color in the mind, produces the idea of a violet blue.

Which is performed by the operation of the rays that are refracted to the greatest degree that can admit of excitement, sufficient to produce the idea of color in the mind; which therefore must be the weakest of all colors.

Between the foregoing degree of refraction and the rays passing in straight lines, the eye can distinguish six more, in each degree of which the rays are less refracted, and consequently strike the eye with a greater impulse, by which the eye is proportionably more irritated in each degree.

The last of which, or the greatest degree of irritation which the refracted rays can ex-

cite, produces in the mind the idea of a deep scarlet ; which must be the strongest of all colors.

The rays of light, thus retarded, are not at once restored to their velocity ; for, when reflected from a substance of a certain color to another object, and from thence to the eye, their operation on it is such as to communicate the idea of the color of the first substance to the mind, as being in the last object.

And it is rational to suppose it must be so ; for any substance which is reflected or rebounds, must rebound with a velocity proportioned to the velocity with which it strikes the object of resistance.

If the rays of light are retarded, by only glancing against a substance sufficiently to refract them, it may be asked, why they should not be more so by striking against an object in such manner as to be reflected or rebound ? the answer is, that the rays of light were designed, in part, for the medium of vision, and were constituted to answer that purpose, in which it is necessary that they should retain their pristine velocity, in all cases, except that of communicating the ideas of colors ; and when they strike against an object, they may be reflected or rebound, as much, or much more, by a power of re-

pulsion, which they possess toward objects, than by any elasticity; (their possession of which in any degree is doubtful) and that, by the laws by which they are governed, they must move from one object to another, with exactly the same velocity with which they arrive at this world, excepting as before-mentioned. For any color or shade, placed before a mirror, from which the rays are reflected to the glass, and from thence to the eye, reflects the shades very nearly, as they appear in the object.

The excessive celerity with which they move, requiring not more than ten minutes in their passage from the sun, (which is at the rate of 100,000 miles in a second of time) renders it utterly impossible to discover a difference in the velocity of the rays of light, if they vary at all. But, when they pass so near to a substance as to glance against it, or by the resistance of their repulsive power, to be, without touching, turned in their course, it is easy to conceive, that they may thereby be retarded; when, if the same rays had struck so directly against the substance, as to have been reflected, though not directly back, they would have rebounded with the same velocity with which they struck the object.

Whether the idea which the mind annexes to objects, by that degree of excitement on the eye that is produced by the rays of light passing with their natural and unretarded velocity, (which is stronger than any of the seven foregoing) ought to be considered as a color, or not, is doubtful. But, that such white or light appearance is a compound of the seven foregoing, is still more to be doubted ; for the experiment which has been appealed to, to prove it such, is at least suspicious ; as the seven powders, which represent the seven colors, must be triturated or rubbed together, to an impalpable fineness, so that no particle is of sufficient size to reflect rays proper to exhibit either of the seven colors ; by which the mixture loses the particular property of reflection, that the simples possessed, before trituration, and instead of reflecting rays to exhibit ideas of all colors, has not power to excite ideas of any.

If, to denominate an appearance, a color requires it to be produced by a mode of operation of the rays of light, different from that in which they pass from the sun to the earth, and from one object which has no particular power to alter their movement to another ; then white may justly be said to be no color. For the appearance of white is produced by those rays which pass in straight lines, or

with the rapidity of those rays in Sir Isaac's experiment, which have suffered no reflection to lessen their velocity.

It has already been observed, that the rays of light reflected from a second object, excite in the mind the same ideas of color, as from the first.

This operation appears to be conclusive proof that it is the reducing of the velocity, and not simply the refraction of the rays, that causes the different ideas of color.

When the end of a rainbow seems to appear among trees, &c. those objects about which it is visible, exhibit the colors of the bow. Can any one imagine, that the rays of light which have been refracted by striking the falling drops of rain, from which drops they have passed in straight lines to the tree, must therefore, necessarily be refracted in their passage from the tree to the eye? again; what different effect can the rays of light possibly have on the eye, simply from having been refracted by the falling drops, from which, to the eye, they pass in straight lines? it appears evident, there must be some difference in the mode of the rays passing, other than their refraction, though dependent on it; and there is none which seems so probable as that of the velocity's

being diminished. And is it not easy to conceive, that the diminution of velocity may continue without any great degree of alteration, by one or more reflections, and in that way, the eye receive a degree of irritation, which may excite in the mind, similar ideas of color, in the first and second objects?

Furthermore, we find that refracting the rays of light, does not in all cases, produce an idea of variation of color. The rays may be refracted by one glass to another, by that to another, and let the rays be refracted any number of times, from one glass to another, still they excite no different ideas of color.

And glasses, worn before the eyes, to help the sight, (the utility of which depends entirely on refracting the rays, and thereby gathering them into a focus or point, that the impression on the eye may be increased) produce no difference in the ideas of color; which proves that refraction, without some other operation, does not cause the diversified ideas of color. But if the glasses are of any color, the rays passing through them suffer the like alteration, as if they were reflected from a substance of the color of the glasses; yet the rays are no more refracted by the colored glass than the white; which again proves that color does not depend solely on refracting the rays of light.

And if it can be made to appear, that the rays, by glancing against an object, receive a rotatory motion, which causes the different degrees of stimulus on the eye, and thereby produces in the mind the different ideas of color, I shall be content to adopt that principle.

The arts of dying, painting, &c. also the productions of nature, which excite in the mind the various ideas of color, plainly show it cannot be simply the refraction of the rays of light which produces that effect.

And it clearly appears, there are certain substances which possess a quality of reflecting the rays of light; some with greater, some with less degrees of velocity; but with innumerable different degrees. The art of dying consists in incorporating those matters into the substance of the cloth, &c.—for instance: to reflect the rays with a degree of velocity, proper to excite in the mind, by their irritation on the eye, the idea of the color of violet blue, those ingredients which are formed by nature for that purpose, and by the experience of the artist found to produce it, must be incorporated into the substance of the cloth, or painted on the surface of the canvass, &c. of which kinds of matters or compounds, there are seven, which reflect the rays of light with velocity, to excite the

seven simple or primary colors, produced by Sir Isaac's experiment; besides which, there may be produced innumerable shades or mixtures.

Will any one hazard an opinion, that those substances or compounds have a power to reflect the rays in an angular direction, any more than they are so projected from the sun? or, that having been refracted within the substance of the cloth or paint, from which they are reflected in straight lines to the eye, can enable them to produce those particular effects, from such a movement, anterior to their exit from the object to the eye, and that without any thing different in their manner of existence or movement, when and after they leave the object?

Is it not easy to conceive; that some substances may repel the rays of light less powerfully than others; and that there may be seven of those matters, which possess different degrees of repulsion to the rays of light, of which there may be an innumerable number of compounds, each of which may produce a different shade?

Let one turn his eyes to the foliage and herbage of summer, and he must acknowledge the different shades of green only, are

innumerable; hardly two leaves appearing of exactly the same green.

The rays which are reflected from the surface of the substance thus colored, to another substance, as may be seen in many instances, convey to the mind the idea of color from the second surface, in appearance the same as if it originated in it, in the same manner as has been before observed, of the rays reflected by the falling drops of rain, which gives the appearance of the bow.

When revising and attempting to correct these sheets, it was considered necessary, more particularly to explain the operations of external matters on the various organs of the body; whereby the mind receives or forms that infinite variety of ideas with which it is stored, and in most instances delighted.

It seems evident that all sensation is the effect of irritation or stimulus, applied to a part susceptible of its operation. And to that sensation which is most common and universal in the body, we give the name of feeling; such as the operation of all harsh or smooth substances, applied to the external

surface; or of a dagger or other substance, within the flesh; or of acrimonious or any morbid humors, whether received from without, or produced within the body. But the nicer operations, on the nobler organs, are also as entirely produced by irritation, as the aforementioned; and the sensations caused thereby may also be denominated feeling, with equal propriety as the others.

To those operations, produced by external objects, on the body generally, we give the name of feeling.

For instance; if a stone comes against one's toe, a cake of ice against one's hand, or a block of wood against one's nose, we say we feel them; but these are all different substances, operating on different parts. But when the rays of light strike the eye, the undulations of the air affect the ear, or the saccharine particles of sugar are applied to the tongue, we denominate the consequent sensations, seeing, hearing and tasting; not considering that the latter, like the former, are nothing more or less than feeling, produced by the irritation of different substances, on different parts.

It is necessary to have different words, to express operations on different parts of the body. But the misfortune, in the present

case seems to be, that erroneous ideas are occasioned by not considering that the difference is in name and part only, and not in reality; it being incorrect to suppose we have five senses, for we have only one, viz. the sense of feeling.

More clearly to exemplify this, let us turn our attention to what are termed the five senses. When a post or other substance, comes against my head, my hand, my foot, or any other part of my body, it may with propriety be said, I feel it; for an irritation is thereby produced, on a sensible part, by which the mind is impressed with an idea, that such substance has touched the particular point to which it is applied.

The organs of sight only, can feel the rays of light; for no other part of the body is capable of being sensibly affected by their feeble impulse, unless they are so accumulated as to cause the sensation denominated warmth; in which degree however they are insupportable to the eye.

The inconceivable sensibility of this organ is beyond all conception; far exceeding any other part of the body. So, also, does its usefulness as much exceed any other, whether considered as conducing to happiness or misery: for instances are not want-

ing of sudden death, from the joy or grief produced in the mind, by the eyes' only feeling the gentle impulse of the rays of light. A woman has fallen dead, by only feeling the irritation of the rays, striking the retina of the eye, by which the mind was made sensible of the return of her long lost son, whose life had been despaired of. It is likewise reported, that persons of delicate and debilitated habits have suddenly expired, by the eyes' feeling the rays from an object which excited in the mind the sensation of horror.

And the usefulness of the eye appears in its enabling us, above all other organs. to procure knowledge, food, clothing, and all things necessary for convenience and happiness; and the pleasing information thence received from all things around us is beyond conception. Nor need we be surprised at the exceeding sensibility of the eye, when we consider the curiosity of its structure.

The eyebrows are placed over the eyes, sufficiently open to admit light to pass through, but thick enough to prevent any destructive substance from falling into the eyes, without notice; and also to prevent too vivid a shower of the sun's rays from injuring them. Nextly, the eyelash, a row of stiff hairs, projects erectly from the margin of each eyelid, which, by being brought near

together, may also prevent injury from the vivid light, but yet admit enough for the purpose of vision ; and which cannot fail, when touched, of giving notice, by the titilation at their roots, to close the eye, that it may avoid injury.

We then find the eyelids, which are not only under the power of the will, when required to close, but which irresistibly and unavoidably close, at notice of danger ; under which rolls the eye in its socket, covered with a fine, smooth, pelucid membrane of exquisite sensibility, thick enough to resist the air and the heterogenous matters which float in it : under this are situate various lamellæ of humors, separated by membranes, all of which are perfectly transparent, and so constructed, as to converge the rays, like a burning lens, and concentrate them into a focus or point, when they arrive at the centre of that most exquisitely sensible of all parts, the retina ; on which, the stroke of a comparatively few rays, is sufficiently to be felt, to communicate to the mind the idea of vision ; not by painting the image of the object, or by forming a shadow on the retina, but by the sense of feeling.

For if the image or shadow were on the retina, it could communicate no ideas to the mind, without another eye, or some organ

beyond the first, to be operated upon by the image or shadow, to communicate the sense of vision to the mind.

I have no objection to the term seeing, but to the error which arises from supposing it performed in a different manner from the sense of feeling in other parts. To be clearly understood, it is necessary to denominate the sense of feeling in the eye, differently from the same sense in the fingers, &c.

The disadvantages, by suffering cold and other inconveniences, on account of the external ears standing out from the head, are greatly overbalanced, by the conveniency of the increased sound, or power of the undulations of the air.

The form of the external ear is that which could not have been exceeded, for the purpose of concentrating the waves of the air, in the same manner as the chrystalline humor of the eye does the rays of light; by which mechanism, the power of those undulations is brought to a point, when they arrive at the tympanum or drum of the ear.

And this power is greatly increased by the elasticity of the external ear, whose inner substance is a most springy cartilage: which increase must have been lost, if, instead of

projecting out from, the external cavity had been sunken into the head.

This elasticity may become evident to any one who will touch the outer part of the ear very gently with the finger, which will cause a sound to the person, equal to the same touch on the cord of a viol.

We cannot contemplate the moveableness and elasticity of the air, but with admiration. For almost the gentlest touch of two substances, or the gentlest whisper through the lips, may (notwithstanding thousands of other undulations are moving in every direction in the atmosphere) be felt to touch the sensible tympanum; from which the mind receives the idea of such operation.

Not only no two of the human race can easily undulate the air with their tongues, so as not to produce a different feeling on the drum of the ear; but among all the tribes of birds, beasts, reptiles and insects, there is none which may not be distinguished from the rest; and also, each individual from the rest of its species, (which is more especially the case with the human) by difference of key, of shrillness and the endless modes of articulating sound: all of which, if the mind were capacious enough to receive them,

would be literally infinite ; for no finite mind can comprehend them.

Again ; the undulations are surprisingly strong, for they may in some instances be felt by the hand, &c. If a cannon is fired near a house, whose walls are tight, the doors and windows closed, the undulations thereby produced will so press against the glass, as to break such a number of squares as will let in sufficient air to preserve the remaining—which may be prevented by raising the windows. Is it not plain, that if all were tight, excepting a hole of two or three inches diameter in the wall, and the hand or cheek were applied to it, that a force sufficient to break the glass, could be felt? but the hand or cheek, not having been accustomed to receive impressions from such waves of air as those by which the mind derives ideas of sound, when applied to the ear, finds in the former, no analogy to the latter.

Yet the pressure of the undulation of the air against the hand or cheek, is as intelligent to an adult, as the same operation is on the tympanum to a new-born infant, who has not learned, by habit, the cause of such wave.

The tongue, pallet, &c. composing the organs of taste, are not, like the ear, (and more

especially the eye) defended from all things, having a tendency to diminish irritability; but, on the contrary, are exposed to the operations of hard, rough and acrimonious substances—to heat and cold—to the atmosphere, with all things which float therein; by which means, some part of the acuteness of sensibility must be blunted. Yet a provident Creator has furnished those parts with innumerable small glands, whose excretory ducts constantly discharge a slimy, mucilaginous matter, on their surfaces, whereby an acute sensibility is preserved; so, that the tongue can feel a difference, in things applied, that cannot in the least be discerned by the common organs of feeling. The finger of the most discerning can find no difference between sugar and aloes, or honey and the extract of gentian; yet, when applied to the tongue, it feels the greatest contrast. The sensations from feeling sugar and honey on the tongue, are denominated sweet; those from aloes and extract of gentian, bitter; which excite in the mind, ideas in the highest degree opposite.

And there are hardly two things in creation, which, when applied to the tongue, do not produce different feelings or sensations; to the vast number of which, when we add the inconceivable varieties in each, we find ourselves lost in the unbounded diversities

of taste ! all of which are nothing more or less than the different feelings produced by the application of things in creation to that organ, created for the especial purpose, that we might never lack variety in life.

That exalted part, the head, is furnished with another organ of exceeding sensibility. The membrane, which lines the inner cavity of the nostrils, on which is spread the olfactory nerve, possesses a surprising degree of accuteness of discernment : for the inconceivably minute particles of the effluvia, which exhales in unremitting showers from all substances, can be distinguished by the irritation or feeling which they produce, when applied to the aforesaid membrane ; the situation of which is most convenient for the reception and application of such effluvia, when floating in the air. We know of no land animal that can live without respiration ; in which the air is alternately inspired and expired, in continual succession, through the nostrils, which are not straight, but curved : hence, the air must strike, with considerable force, against some parts of that membrane, and the effluvia which are carried with it, must also be forcibly and continually applied.

And, notwithstanding its corpuscles are small beyond conception, and their diversity surpasses imagination, they can be felt and

distinguished by the aforesaid membrane ; whereby the mind becomes sensible of the different substances from which they originate. However, the human mind is less accurate in its discernments from this than other organs ; yet there are some animals (dogs, &c.) which seem to discover by this organ, more perfectly than any other : for although the object be full in their view, they appear never to decide without smelling.

In this again we have another organ which furnishes us with endless variety.

Concerning the general sense of feeling, it is enough to observe, that in the spiral lines, near the ends of the fingers and toes, there seems to be a power (which is much increased by habit) of discerning, by the touch, the different forms, &c. of objects.

From the preceding observations, it seems to appear, that there is one sense only, and not five ; and that notwithstanding there is a great difference in the degrees of sensibility, yet the operation by which they are exercised, is essentially the same in all.

Any degree of operation, by the rays of light, on the organs of sight, which is not sufficiently powerful to convey to the mind the idea of color, is nothing more or less than the rays of light being perfectly felt by the eye, without any other effect or idea excited in the mind, than only that of information received, that the rays from some object have come into the eye.

Nor does the mind, from such a degree of operation on the eye, conceive any figure, dimension, extension or distance of the object from whence they come ; nor, when they are increased, so as to produce the utmost irritation that the eye can bear, does the mind receive or form, through the organs of sight, any idea simply by the operation of the rays of light, excepting the aforesaid notice, that light has arrived into the eye, and also the idea of colors ; the ideas of figure, dimension and extension being formed in the mind, solely from the movement of the eye in its socket, and the turning of the head on the upper joint of the spine, called the atlas. The ideas of distance are formed in the same manner, and from the mind's enumerating and putting together the distances between objects of arrangement and comparison in the line ; by which a judgment is made up, of the distance of the object in view, with more or less accuracy.

To help comprehend those operations of the eye, by which the mind receives or forms ideas of figure, extension, &c. of objects, let us suppose a cross with two arms, each twenty feet in length; one horizontal, the other perpendicular —When facing such a figure, the eye, from its inconceivable quickness, seems to comprehend it wholly at once; but by carefully observing, we shall find we do not see two of the smallest parts at the same time. When the eye is fixed in a direction to receive the rays from the right hand extremity of the horizontal arm, to be placed in a situation to receive them from the left hand extremity, the eye must roll in its socket, or the head turn on its atlas, a certain distance; which movement of the eye, &c. is the only operation from which the mind forms an idea of the distance or extension, from one end of the arm to the other; the mind receiving information, by the operation of light on the eye, that there is an object directly before it, by turning the eye in its socket, in a direction to receive the rays the whole length of the arm, to the extremity on the left, (or, in common language, the eye following the arm) it receives information of the object's continuance.

Thus the mind forms an idea of the figure of the horizontal arm; and from habit, (by the distance the eye is felt to roll, or the

head to turn from its situation to receive the rays at one end, to a situation to receive them from the other) can form a judgement somewhat correct, of the length or distance from one end to the other; and in the same manner of the distance from side to side; and by compounding or putting together the several ideas, it may have an idea of the figure of that arm.

By the like movements of the eye, the mind may have an idea of the figure of the other; and by similar movements, can find the two arms are placed crosswise of each other, thereby acquiring the idea of the figure of a cross. And if two shorter arms were placed across the centre of the two former, ranging mid-way between the longer, and boarded round the extremities of the whole—by the like movements of the eye, the mind can acquire the idea of a figure with a scolloped edge. And if to the foregoing, smaller figures of plants, flowers and animals should be added; by the same operation, the mind may acquire, not only the idea of the whole figure collectively, but of each individual figure of which it is composed, and that without any figure being formed in the eye.

So exquisitely sensible is the mind of the least movement of the eye, that its move-

ment to accommodate itself to receive the rays from two of the least discernable objects, when touching each other, will give the mind a just idea of which is at the right hand and which at the left.

In matters of small consequence, the mind, by a glance of the eye to the object, forms an opinion of its extension ; but in matters of importance, the mind deliberates, while the eye carefully surveys the object—for instance ; if the design in the mind is to ascertain the number of cubic feet on the side of a building, the eye is moved from a direction to receive the rays from the right to the left side, and from the left to the right ; from top to bottom, and from bottom to top ; from corner to corner, and from and to every part ; which movements of the eye are quickly and often repeated, until the mind, by considering also the distance of the object from the eye, and comparing the movements of the eye with what it has ascertained by previous observations and measure, by rule of feet and inches, becomes satisfied as to the number of square feet the surface contains. The judgment so acquired, may be near the true number ; but matters of judgment or conjecture are not expected to be perfect.

Yet, without the sensible effects of the motion of the eye in the mind, there could be

no idea of the extension, distance, &c. of objects, by seeing: for simply the rays operating on the eye, and thereby communicating to the mind the idea of an object from whence they come, though they should be reflected from every quarter, could not cause the mind to form any idea of the extension, &c. of the object; as appears, by viewing an object of uniform surface, through a long slender tube, before which every part of the surface may be discovered, by moving it in such a manner as to have no other object seen by the eye. The motion of the uniform surface of the object so moved, and viewed by the eye when confined and without motion, is not discoverable by the eye, nor does it occasion an idea of extension, &c. of the object.

Again; suppose a person, sitting in a house, ten feet from a hole through the wall, one inch in diameter; and a board without the house, ten feet in length and one in bredth, moved irregularly, back and forth, up and down; all the movements short and indirect, but such that every part of the board may be seen more than once—in this case, although no part of the board has escaped inspection, yet the mind can have formed no idea of its extent or dimension; because the board has moved and not the eye, and the movement has been without any other thing

being admitted to view, as an object of arrangement or comparison, by the aid of which to guess at the distance, &c.

Distance is judged of by the foregoing principal.

When we behold an object (such as a tree, &c.) a long way from us, the mind forms an opinion of the distance, by turning the eye from the place where one stands, so as to receive the rays of light from the surface of the earth along the whole distance betwixt the eye and the tree; which movement is often repeated, and the eye often turned backward and forward, from or to objects in or near the line of direction, which are used by the mind as marks of direction and comparison, to enable it to discover more accurately, the movements of the eye, &c. By dividing the distance into such parts as the intervening objects can readily be found to admit: and if in the course of observation there happens a valley, in which the eye loses its discovery, it occasions a chasm in the calculation, which is the cause of error in judging of the distance; for the hills on each side are so much in a range from the eye, that the two seem nearly together, for want of objects or surface, whereby to compare the distance.—But when the whole surface can be seen, or objects are frequent to judge the distance by,

after the eye has fully surveyed each, and the mind carefully compared, enumerated and put together the distances, the judgment of the mind thereby is as acurate as ought to be expected.

The mind is also assisted in the decision, by the reduced appearance of the distant objects, which it, almost without our knowledge, carefully compares, one with another, along the course of its inquiries, having, from habitual experience, learned the degree of diminution in appearance for certain measured distances; and having by like experience, learned the distance at which certain small as well as larger objects can be distinguished; and also, by the degrees of variation in the appearance of the colors of the distant objects, from the known colors of the same, when near by—for the colors diminish in brightness as the distance increases, as well as the apparent size. To all of which the mind carefully attends, and compares one with another, whereby it is much aided in its calculations.

Neither the dulness of the colors, nor the diminution of appearance, above noted, are the effect of any diminution of the velocity of the rays of light, by the distance they have come, but of the rarity of the rays which strike the eye; for the rays of light being

sent from the object in all directions, must move in divergent lines, whereby the number which arrive at any given space, must decrease as the distance increases; in consequence of which, although the colors remain the same, the eye is more feebly irritated, and hence the mind is more dully affected with the idea of color, &c.

Notwithstanding the rays which are fewer in number operate less powerfully on the eye, as well as those which have suffered diminution of velocity, yet a duller or less sensible operation on the mind is not all the difference in the effect of the power's being lessened in the two different manners; for the degree of power being lessened by a diminution of velocity, may produce quite another sensation on the mind, than that from a deficiency of power, by the rays' being fewer in number, although the diminution of power should be exactly the same in the two cases.

Which difference is evident in many of the operations of nature and art. Suppose an ounce ball project from a gun or otherwise, with sixteen degrees of velocity, (and one of weight) against a door, hung moveably on hinges, and it will pass through the door without moving it: but if a spear, the end of which coming against the door, is exactly of the same dimension and form as the ball,

but sixteen times heavier, is projected with one degree of velocity (which must cause each of them to possess the same power of motion) and strikes against the door; instead of piercing through, it will move it on its hinges, till the power of motion is overcome by the resistance with which it meets. The same kind of operations are observable in many other things; as is well known to the smith, who understands how to vary the heft of his hammars and the quickness and force of their use, in the different operations in his business. Why then may there not be a difference in the operation of the rays of light, when their power is diminished by different causes?

From which it is evident, that the appearance of the object becoming fainter, without any alteration in the idea of color, in consequence of fewer rays coming to the eye, furnishes no argument against the doctrine of colors as before stated.

The apparent diminution of size in distant objects, is the effect of the smaller distance the eye is required to move in its socket, to be placed in a situation to receive the rays of light from every quarter of them. This may be easily understood, by one or two experiments, which may be performed by any one who will place himself ten yards from a

building of middling size, and he will there find he must move his eye a material distance, to place it in a situation to receive the rays from all parts of the side next him; but let him remove one thousand yards from it, and he will there find he need move his eye but a small distance to survey every part of the same. Again; find the distance to place a small platter, (perhaps twenty yards) so as to require the same movement of the eye, from a situation to receive the rays from one side, to a situation to receive them from the other, as it does to receive the rays from one side of the sun's disk to the opposite, and it will appear of the same bigness of the sun, though the sun is really millions of millions of times larger. But suppose the sun brought within one hundred miles of the eye, it must then turn nearly one third of a circle round, to receive the rays from both sides.

If the eye is susceptible of seven distinct degrees of irritation by the rays of light impressing on the mind, agreeably to Sir Isaac Newton's experiment, seven distinct ideas of color, (which perhaps must be admitted, notwithstanding every one has not the sagacity clearly to discern seven in the bow, &c.) it exhibits another instance of the uniformity in the operations of the laws of nature; for the ear is capable of receiving seven distinct sensations of irritation, by the undulations of

the air, impressing on the mind seven distinct ideas of sound; among which there are certain undulations which seem to follow each other, in such close succession, that the irritation of the one has not ceased, when the other begins to operate on the tympanum, so that they operate partly together, impressing on the mind the most agreeable sensation— The stimuli so compounded is called by musicians a concord, of which there are several degrees more or less perfect.

This peculiarly agreeable sensation seems to be produced by circular undulations of the air, moving in waves that intersect each other, and move with equal velocities, so that the intersections continue until the undulations cease.

Which intersections cause the tympanum to receive the force of two undulations, partly at the same time; and by their angular direction, to strike it in a manner that no other undulation can. This degree of irritation and manner of application, is that which above all others gives pleasure to the mind.

To acquire an idea of the modus operandi, let scattering drops of water be caused to fall upon a still pool or cistern of water, and it may be observed that the circular waves or spheres produced thereby will be increased,

in proportion to the distances they have moved; by which the intersections of their circles will be continued until the water becomes nearly quiescent. On similar intersections of the undulations of the air, does the harmony of sound depend.

There are but seven distinct sounds, within which the above consonance of operations of the undulations must be effected; for experience proves, that the eighth, or octave, whether higher or lower, becomes the same, with regard to the above operations. And it is evident, that octaves are produced by undulations, which differ from those producing unisons, only in the quantity of air in motion; which, whether greater or less, moves with the same velocity: and notwithstanding the mind can discern a difference between octaves and unisons, yet the undulations are in perfect unison as regards the motion of the waves of air. And although musicians distinguish octaves and unisons by different appellations, still the undulations which produce them, are so perfectly in unison, that when the bow is drawn on the C string of a base viol, perfectly in tune, and a finger is placed on the G string, at C, the G string will vibrate without the bow's touching it, almost as much as if the bow were drawn on that alone.

From this experiment we also discover the power and force of the undulations of the air; for to cause so heavy a string and so tensely distended, so powerfully to vibrate, must require no small energy of so rare a fluid as the air. It seems evident that the tension of the two strings is such as will vibrate in unison; (*i.e.* in equal spaces of time) for the finger being moved either way, so far as will vary the sound a note, will prevent the vibration.

So also, let a string of a violin be in unison with one of a base viol, the violin on a shelf; the bow being drawn on the string of the base viol, the cord of the violin at some distance will vibrate and sound audibly, by the power of the undulation of the air, caused by the vibration of the base viol string. But the two strings must move in perfect unison, which is the most perfect but not the most pleasant concord.

So great is the quantity of fire evolved from the productions of the laws of nature, while decompounding, that there seems to remain no room for doubts concerning its being a component part of all compound sub-

stances. Its minuteness, and the rapidity with which it is dissipated, in some instances entirely, and in many, almost entirely, prevents its discovery; but in all cases where it can be brought to operate directly on an object, while evolving, the effect manifests incontestible evidence of a surprising quantity—as when by friction, a small quantity of iron is decompounded, the fire that is evolved will not only cause a cistern of water to boil, but continue its boiling for any length of time.

Fire being connected with all compound substances, affords an unbounded field for inquiry; and the subjects which become the theme and reflection of these inquiries, will, as has been heretofore practised, be attended to as they occur to mind, without any regard to system.

The excessive stimulus of fire, when applied to living animal flesh, produces an indirect debility, which, when powerful, destroys all motion and life, and eventually produces a solution of continuity; whereby the cuticle is disunited from the true skin, and the most excruciating pain is experienced. The subtle, exuded fluids, lodged in the interstices of the skin, and the lymph from the ruptured lymphatic vessels which are not utterly destroyed, but excited to greater

action, by the stimulus of the fire, are forcibly discharged into the opening; hence vesications similar to those produced by the stimulus of cantharides.

The nerves, which are the life-chords of pleasure, are also susceptible of the most excruciating pain, and as faithful centinels, are placed in every part of the body, to convey to the mind the presence of danger and the operation of injury. To them the operation of no hurtful agent in nature is more irksome than that of fire.

It is in the fleshy substance, (of whatever kind it may be) betwixt that in which life is utterly destroyed, and that which is sound, that such insupportable pain is suffered; and it is for the purpose of procuring ease and safety to that portion of flesh, that the attention of the surgeon is called. Regular practice admits of two modes of treatment, which, in operation, are diametrically opposite; one or the other of which ought to be more generally followed. The one is instantly to immerse the part in cold water; or, by absorbing water with indian meal or other substance, to apply it in form of a poultice; and when becoming warm, which is manifest by the return of pain, it is to be removed and a cold one applied from time to time, until it may remain on the part and become warm,

without a return of pain. The cold, in whatever way applied, should be continued, until life is utterly extinct in the parts which are greatly injured.

The well known sedative operation of cold quickly palsies all sensation in those fibres, which, from the stimulus of fire, suffer pain seemingly insupportable; and by the same sedative power, prevents returning sensation in those that have suffered a temporary cessation of sensibility, by a more powerful stimulus: by which operation, pain is almost entirely prevented. But the consequence is, that the flesh, so benumbed, must perish and slough off with that above it, which had in the first instance suffered a total loss of life by the fire; leaving an ulcer so much deeper, to granulate and cicatrise.

The other method is, instantly to apply stimulants; such as spirit or oil of turpentine, mixed with an equal quantity of sweet oil; or the warmth of fire at some proper distance; or a dead coal, from which all emission of fire has not ceased; or other convenient stimulants—by which those fibres that have lost all sensibility, but in which life is not utterly extinct, are resuscitated and sensation returned to them, with excruciating pain: which pain will be more acute, but of shorter duration, in proportion to the de-

gree of the stimulus applied. By this last method of treatment, much more pain is endured by the patient, than by the former; but much flesh is preserved and restored to life, consequently much less to slough off; and the ulcer being less and not so deep, will become sound much sooner. It is therefore to be left to the discretion of the patient or his advisers, which method to adopt.

When gently stimulating vegetables (bruised or scraped, and formed into a poultice) are applied, as is often practised, many of the fibres that had been, in the first instance, entirely palsied, by the indirect debility produced by the stimulus of the fire, will be for many hours, and in some cases for days, slowly returning, one after another, to sensibility and life, with unremitting pain and uneasiness; by the irritation of which, a greater or less degree of redness and inflammation must be produced; and the good women, without hesitation, pronounce that the fire is not taken out, and either a sedative or stimulating remedy is applied; by the operation of which, in one or the other of the foregoing ways, the injured fibres are sooner or later brought to one of the aforementioned states of ease, when the inflammation spontaneously abates, and the idea of remaining fire is removed. But it is altogether absurd, to suppose that any fire, which was communica-

ted to the part, under whatever treatment, remains in the flesh many minutes after the burning.

It is very probable that the slowly returning sensibility and life in the fibres of the fleshy substance, injured as above, may, by their irritating tention and attendant pain, for a length of time, produce an inflammation which may prove destructive to a portion of the before uninjured substance, whereby a very disagreeable ulcer may be produced, which might have been prevented by the application of cold water in the first instance. If the last mentioned idea is correct, also considering that stimulants are not always at hand like cold water, the latter may be preferred.

Caloric is defined to be "the principle of heat, latent heat and fixed heat;" phlogiston, "to burn with blaze or flame;" hydrogen, "the base of inflammable air and of water."

We are told when fifteen parts of oxygen (the principal acidity, or sour getter) are chymically and closely combined with

eighty-five of hydrogen, they produce a new compound called water.

It must be admitted that the foregoing are hard names; but there appears somewhat much harder than those appellations!—if the foregoing production is really a matter of fact, it is truly surprising.

In order clearly to understand the matter, it seems necessary to have correct ideas of at least some of the elementary or component parts of which combustible substances are compounded, and the manner and effect of the decomposition of those substances; and also, just ideas of water, not overlooking oxygen in our inquiries.

Many arguments have been used to prove that fire is an element, and the effects of the decomposition of fuel by combustion and otherwise, seems sufficient to substantiate it.

I know of no more positive evidence that could be adduced, that fire is a component part of wood, than its being evolved in surprising quantities while decompounding; than which, nothing can be more obvious, nor more forcibly impressed on the senses of feeling and seeing. And I feel no disposition to distrust my senses; for they are the

only organs by which I ever received any evidence, in any matter whatever.

Wood, &c. when deprived of its vegetable life by the operations of the laws of nature, gradually proceeds to a solution and decomposition of its parts, in which state, under certain circumstances, it emits a very conspicuous glow of light, which can be no other than the fire evolving slowly, but in the same proportion that its other component parts are disunited. And there can be no doubt, that whenever light can be discerned by the eye, that were the sensibility of our proper organs of feeling sufficiently acute, we could also feel the warmth.

Indeed wood, when in a perishing state, in some instances plainly shows heat; and plants that decay much more rapidly, exhibit very sensible heat. But it is seldom, if ever, the case, that plants, when decompounding without combustion, produce light that can be perceived by the eye, although the quantity of light is vastly greater than that evolved from the wood; the reason of which seems to be, that the light evolved from a mass of putrefying plants, like the rays which are making their exit from a heated iron, are emitted in irregular and cross directions; being conveyed to no point, in sufficient numbers, to have any sensible operation on

the eye. But putrefying wood, fish, &c. have on their surfaces, a mucillaginous slime, which, when properly moistened, like varnish, or a solution of gum arabic, &c. causes the rays to pass off in regularly eradicated lines ; by which, although in less quantities, yet they come to the eye more numerously, thereby having a sensible effect, when the grosser organs of feeling can discover no warmth. In this we have an instance of the operation of light, without discernable heat.

But the quantity of fire evolved from wood, &c. is conspicuous indeed, when decompounded by fire. This fire and light are one and the same essence, and are the caloric, as above defined.

It seems necessary now to inquire concerning its mode of operation, and different appearances.

It sometimes appears to glow with a red heat, like heated iron—at others, to flame or blaze, as if it were a fog or cloud of fluid fire ; but these are only different modes in which it appears.

When fire is applied to a log of well seasoned wood, and continued until a decomposition is excited to operation, or, by friction, (as may be the case) either exciting cause

may afterwards be removed; for the fire, thereby evolved, will be sufficient to continue the decomposition of the wood, till the whole is reduced and scattered in various forms.

But this reduction is not perfect as to all the component parts: the caloric, (or fire) water, oil, &c. seem to be entirely disunited from the other component parts, and dissipated; while the saline, terrene, and perhaps many others may still remain in compound states.

Or the process may be so managed that very little of the caloric is evolved; no more than is sufficient to exhale the watery part, and most, if not all of the oil in the composition of the wood, whereby it becomes carbone, (charcoal) which possesses more caloric than the same volume of the wood of which it is made, and from which, when fire is communicated thereto, and a strong blast of air applied to hasten the decomposition, evolves a very great quantity of caloric, producing a most intense heat. But the decomposition of the log (as above-mentioned) is gradual, and the fire, evolved slowly, appearing red like hot iron, and almost entirely without blaze: differing widely from the appearance of fire, when spirits, oil, &c. are decompounded thereby; which exhibit no appearance of fire, except flame or blaze—

all appearance of fire ceasing, as soon as the blaze is extinguished, or ceases. This difference in appearance has given rise to an idea, that the two are not produced by one and the same essence, and different appellations have been invented and applied, whereby they are known and distinguished : to the appearance of solid substance, when burning, the appellation of caloric—to that of fire consuming fluids, &c. phlogiston, or hydrogen ; which last seems to be considered as the principle or base of phlogiston, which is the essence of blaze.

But is it a hard thing to conceive, that when a solid substance is slowly decompounding, and the fire evolved sparingly, there should be no appearance of fire discovered any distance, but only at the very surface of the substance which emits it ? and is it not easy to conceive, that when liquids (such as spirits, oil, &c.) are consuming with rapidity, and the fire evolving in great quantities, the compactness or thickness of the particles of fire emitted may render it visible, after having passed in diverging directions some distance from the substance from whence they have arisen ? and blaze is no other than fire emitted in showers sufficiently thick to be conspicuous ; nor is there any substance in such fluids, to retain the operation of fire, any

longer than it thus passes off in a conspicuous shower.

To cause this matter to appear more plain : Suppose a seasoned log of wood to be split in the middle ; no one will dispute both halves being the same in the experiment— set one on fire whole ; let a carpenter, with his plane, work the other into the thinnest shavings, to which apply fire ; and according to the modern ideas and terms, the fire in one will be caloric, and in the other, phlogiston.

The thin and perfectly dried shavings will burn almost as much with blaze, as spirits ; and the fire will remain but a short period longer, after the blaze is extinguished ; and it must be extraordinary if the blaze, once extinguished, should rekindle again of its own power, any more than in the spirits— all this different appearance, from only altering the figure of the wood. Now will any one pretend that there can be any difference in the fire which consumes the two halves of the log ?

Wood, reduced to coal, (as above) burns with but little blaze ; the reason is, the coal being deprived of all its aqueous fluid, affords no exhalation of particles of water to pass off with those of fire ; both of which, if they

were emitted together, would, unitedly, be much more conspicuous than fire alone, and be visible a much greater distance from the substance from which they were emitted.

Again; according to the operation of exhalation, as heretofore explained, when the rarefied steam or exhalation becomes overcharged with fire; instead of passing by its levity directly upward, it is thrown into eddies and lateral movements, by which it is dissipated and repelled in every direction, and thereby the blaze near its source becomes more visible—the effect of the fire may be experienced much farther from its source laterally—the air becomes much more charged with fire, than when the steam or smoke ascends directly upwards, and the heat is suddenly removed a great distance from those who depend on the comforting warmth transmitted from the fire.

The same operation is experienced by the blacksmith; and is also similar to, and produced by the same principle and law of nature, as that concerning the degree of heat which can be communicated to water in an open vessel; of which it has been heretofore mentioned, (page 62) that no art, by augmenting the fire, under and about the open cistern, can raise the heat of the water above 212 degrees of Fahrenheit's thermometer.

The reason is the same in all the last mentioned. As in the open cistern, so in the other cases, no particles of water can remain condensed, when the medium of heat is raised above 212 degrees (as aforesaid;) nor can the medium of heat be raised by any art, above that degree, where there is a sufficient quantity of water to be exhaled.' For, as every exhaling particle of water carries off with it a large quantity of heat or fire, and as every particle of water must inevitably be rarefied and exhale, when in a medium, whose heat, in the least, exceeds 212 degrees; therefore, as long as water remains to be exhaled, the heat cannot accumulate above that degree. So in the forge of the blacksmith—where there is uncoaled wood, which contains moisture, it must irresistably transport the heat from the fire; and it is probable that no art, operating with uncoaled wood, can possibly raise a heat sufficiently strong, properly to weld iron.

And in the decomposition of fuel, when the quantity of fire evolved is much greater than the exhaling particles of water can attract to and carry off with themselves, the smoke is said to be consumed; but instead of being consumed, it is only dissipated in every direction; that near the wood, together with the caloric, giving the appearance of blaze as far as visible, after which, it is not

discoverable by the eye. But the instant the blaze appears, the heat is projected to all sides and communicates the sensation of warmth in all places about the fire. For fire and water, after the particles of water have received as much caloric as they can retain, powerfully repel each other; and the corpuscles of fire are as likely to be repelled downwards, or laterally, as upwards, notwithstanding rarefied water, or steam, always ascends.

Water has already been defined.

Oxygen, "the principle of acidity, or sour-getter," means, in modern chymistry, "that substance which imparts the quality of sourness to natural bodies." It is acknowledged that "the particles of oxygen are too pellucid or too small to be seen by the naked eye, or the microscope; but its addition to other bodies (they assert) increases their weight, and its subtraction, lessens it."

If it cannot be seen nor analyzed, how can it be ascertained that it is the addition or subtraction of oxygen, that adds to or diminishes the gravity of bodies?

Acidity (sourness) seems to belong principally to the vegetable kingdom; for although animal substances will sour, yet it

seems to be the crude parts, or those which are derived from vegetables not perfectly animalized, that become acid; as sourness, when animal substances putrefy, is quickly neutralized and destroyed, by the production of alkali, to which all perfectly formed animal substances seem to have a tendency.

But acidity seems not to be a primogenial substance, but a combination of certain matters, commonly if not always produced by the decomposition of vegetable substances.—And if it is admitted that it floats in the atmosphere, (which is without doubt; for the exhalations of vinegar and other acids can be sensibly smelled) and that the acid effluvia corrodes iron, &c. and that those substances become heavier by its reception, it amounts to no proof that it is a primogenial principle, which, by its own power, turns other matters sour.

Is it not surprising that fifteen parts of oxygen or sourness, and eighty-five of fire, constitute water? I should certainly hesitate, before plunging my hand into a composition known to consist of eighty-five hundredths of hydrogen, or fire, blunted by only fifteen of sourness; for I never discovered vinegar, or any other acid, to prevent the effect of fire any more than other aqueous fluids possessing no acidity.

There are a variety of operations which appear fully to prove, that each exhaling particle of water attracts and carries with itself a great number of the corpuscles of fire; which having been observed, but without sufficient attention, has undoubtedly led to the conclusion above stated, that fire, united with oxygen, forms water; but why some other substance did not appear as probable to be the one, I am at a loss to guess.

There is one appearance in the operation of the laws of nature which seems to justify the hypothesis, that water is compounded of fire and some other substance, with which it is combined—which is, the appearance of water or sweat on the surface of the body, when heat is excited within, by exercise or otherwise.

But if sweat, which in some instances plentifully trickles down the surface of the body, was generated within the body, and therefore did not exhaust the fluids necessary for the economy of the animal machine, there would not be (as always appears to be the case in profuse sweating) a supply of drink required, in proportion to the exhaustion; for if the fluids of the body were not exhausted, there could be no need of an extraordinary supply.

Again; an extraordinary quantity of drink taken into the body, is at least the most powerful sudorific, and seldom fails to produce sweating.

Besides these, there are many other arguments that might be adduced to the same purport; but by an inquiry concerning animal heat, the matter may, possibly, appear obviated.

Animal heat, notwithstanding the many attempts that have been made to account for its cause and existence, seems to have remained an obscure affair: with no small diffidence, therefore, some inquiries will be attempted, concerning its source, cause and effects.

Whatever is received as evidence, that fire is a component part of vegetables, is equally entitled to be received as evidence, in favor of the proposition that it is a component part of animals.

None of all the obscure and mysterious operations of nature are so surprising, as that law which controls the materia solis, on its visit to this our world. Strayed, as it were, from its abode, when it arrives here, many of its corpuscles, by the power of God, (otherwise called the law of nature) are ar-

rested and confined, with other component parts of vegetables, animals, &c. until, by the operations of other laws of nature, they are set at liberty.

By their confinement, they are deprived of their operation as fire; for, although no other matter existing can operate like fire, yet fire, when deprived of motion, loses the power of those operations peculiar to itself.

So much does the power of fire, when producing its own operations, depend upon motion, that many of the greatest philosophers have denied its existence, and ascribed its effects to an intestine motion of any matter excited to such motion; *i.e.* that it is not an existence, *per se*, but a peculiar mode of operation of matter. But if this is admitted, it must at the same time be admitted, that there can be no heat in any but primogenial, uncompounded existences; for if the particles of compound substances were to undergo such intestine motion, it must cause a decomposition; whereby compounds would be destroyed, and their component parts reduced to their primogenial state.

Therefore, fire must be an existence, *per se*; which, when it is not confined with other substances in the growth of compound productions, is often, for a time, detained in

the interstices of compound substances, manifesting by its operation on our senses, when emerging, that it has been thus entangled; which may be understood, from observing an iron or other substance, that has been heat and is cooling.

If the arguments that have been already used, strengthened by the observations, reflections and inquiries of the philosophizing mind, are not sufficient to substantiate the proposition, that fire is an elementary, component part of most compound substances in nature, it is considered that conviction concerning the matter must be left to further time and reflection; which, if the proposition is true, cannot fail to produce the effect.

Hazardous as it may be, it will be assumed as a fact, that caloric, materia solis, or fire, (for the terms all mean the same thing) combined with other substances, forms animal bodies; of which it is by no means the least material; but when thus combined, is as inactive and inoffensive as the other component parts; having power to produce neither the decomposition of that substance of which it is a part, nor any other compound; nor the sensation of heat or warmth, nor to operate as light on the eye; but is compelled by the power of the law which governs it, to submit to a temporary confinement in a state

of inactivity, utterly repugnant to the powers which it exhibits in its unconfined state.

But this confinement by no means destroys its essence: for when, by the operation of any other power, or other laws of nature, it is disunited and set at liberty, it is instantly possessed of all those powers of which it had been deprived; and is capable not only of decompounding every compound substance, and communicating the sensations of heat and warmth, but of light.

Fire thus confined and inactive, is in no small proportion a component part of animal bodies, which are continually decompounding and rennovating, by the application of nutritious matter, derived from animal substances or vegetables, which are also a compound of fire and other materials. These, by the power of the natural functions, are proportioned and applied to increase the growth, or to supply the decays that are produced by numerous means, in such bodies. Hence they are supplied with a necessary proportion of caloric or fire, which, by the various causes of abrasion, distraction, decay or decomposition, is set at liberty, and being thus restored to its primogenial, active state, is diffused through the animal body, which is thereby supplied with sufficient heat or warmth.

This animal heat is greatest about the vital parts, where the vital functions most powerfully perform those offices which are indispensably necessary, for the support of the animal economy. But notwithstanding the decomposition of animal substance is much greater in those parts, and the heat of the body consequently more abundant; yet it is carried by the circulating fluids and otherwise, to the extreme parts, especially in a state of vigor and health, so as to keep the extremities sufficiently warm.

Various are the causes of decomposition, by which the body is supplied with heat.

The operations of the natural functions on the aliment, whereby it is digested and prepared for assimulation with the body, doubtless so far decompounds the food as to set at liberty some portion of caloric in the stomach, &c. which are in the centre of the body, and consequently it is not lost.

The vital functions, by the extreme and incessant velocity with which the fluids are forced through the heart and sanguiferous vessels, and the constant heaving of the lungs, &c. must cause a great decomposition of the substance of the body.

Even the exercise of the animal functions may cause decomposition—for instance; study, thinking and reasoning ardently, debilitate the body.

But muscular exertion surpasses all other causes of decomposition; for by violent exercise, both man and beast suffer a rapid decay of corporeal substance, and experience the most excessive heat through their bodies.

That animal heat depends upon the decomposition of the body, the materia solis being thereby set at liberty, is evident, by the heat in fever: for when the subject is robust and full, the feverish heat is excessive the first days, while the body rapidly dissolves away; but in most, if not all cases, the heat abates as soon as the body becomes emaciated, and little is left to be decompounded and furnish fire to continue preternatural heat.

And it further appears, that those remedies, which, above all others, abate the heat in fever, are such as are most powerful in preventing decomposition or dissolution, viz. peruvian bark, sal nitre, and the effervescing mixture of acids and alkalies; and also, pure, fresh and cool air—at the same time, most cautiously avoiding all contaminated, putrescent, deleterious effluvia.

Nothing perhaps more powerfully prevents putrefaction, or a complete solution of continuity, than the aforementioned bark and salt petre. And the exhalations from effervescing mixtures of acids and alkalies, will restore to sweetness, meat that is tainted. The exhalations from lime, in the most sovereign manner, purifies a contaminated air.

Again; fire cannot be made to burn, but will be extinguished in the medium of those gases which most powerfully resist putrefaction, or the decomposition of wood, tallow, oil, &c.

But such remedies are to be understood to be useful in those fevers which are produced by exhalations or miasmata, from decompounding substances. But yet, excessive heat, in the most violent and truly inflammatory fevers, which depend on the stimulus of excessive fullness, decreases after the first days.

Many have been the inventions to account for animal heat; but still the greatest philosophers have acknowledged, that some yet undiscovered source must be found.

If the importance of the subject, to human life and happiness, is duly considered, few

things will more engross our attention ; for life itself must cease, without its exciting and cherishing influence.

A young animal ; for instance, a chicken, when benumbed with cold, appears to have only the remains of life in a most imperfect degree ; but when placed in a suitable degree of warmth, and so remaining, until by absorbing a sufficient quantity of fire it is warmed through, it becomes resuscitated with the full vigor of life. And every one in this climate has experienced the loss of power in the muscles, to move with activity the fingers, &c. after great exposure to cold ; which will suffice to convince us, that life cannot remain, when animal heat has utterly ceased.

And what is there that affords more pleasure than a certain degree of heat, whether originating in the body and confined to it by clothing, or the bed in which we sleep, or received from without, from the sun or artificial fire ? there is, notwithstanding, a certain medium between the extremes of heat and cold, that is most agreeable to our feelings ; for when overheated, we experience great pleasure by the reception of cold.

But although a particular medium is so extremely pleasant ; and the heat of the ani-

mal body is in a great measure according to the quantity of fire set at liberty, by the decomposition of parts of our bodies, (being abraded and worn away by the operations of that which constitutes life, and which must be replenished by sustenance, or life eventually cease) yet our bodies are so constituted and organized, that they can bear most surprising degrees of cold or heat—cold to any thing short of the freezing point, or heat almost to the degree of boiling, without destroying life.

Governor Ellis observed something similar to this, as long ago as the year 1758.

Professor Cullen long since used many arguments to shew that living animals have an inherent power to generate heat and cold.

As the medium in which we exist is always colder than the natural temperature of the body, except in extraordinary cases, animals stand in less need of the power of generating cold, either for the convenience of the animal economy, or for the purpose of pleasure, than the power of generating heat, which is so essential to life and happiness. The learned professor might, therefore, be in an error concerning the animal power of generating cold, (which, however, would be no argument against the entity of cold) it

being fully sufficient for the purpose of animal economy, to possess a power of repelling an extraordinary accumulation of heat in the body, or prevent its accession; as the following experiments manifestly prove it to have.

It may not be amiss to premise, that the mean heat of the healthy human body is about 97 degrees of Fahrenheit's thermometer. Water boils at 212 degrees.

Dr. George Fordyce, "having undressed himself in his shirt, went into a heat of 119 degrees, and in half a minute the water flowed down his whole body in streams: having remained here fifteen minutes, he went into the heat of 130 degrees:—at this time the heat of his body was 100 degrees, and his pulse beat 126 times in a minute:—in this heat he remained fifteen minutes, and just before he left the room his pulse beat 139 times in a minute, but the heat under his tongue, in his hand, &c. did not exceed 100 degrees."

"Dr. Fordyce observes on this experiment, that there was no evaporation, but constantly a condensation of vapors on his body, and no cold was generated but by the animal powers."

Notwithstanding the admission of the idea of the generation of cold in this experiment would be a favorable argument in proof of the entity of cold, it is believed there is sufficient proof to substantiate the fact without it; and as the design of these inquiries is to discover truth, the writer wishes to avail himself of no argument that is not truly in point.

It was utterly unnecessary in the above experiment, that cold should be generated in the body, to keep its temperature below that of the surrounding medium, provided there was a power in the body to resist the accession of heat; and it has been heretofore proved, that exhalation, above all other things, exhausts heat or fire from all heated bodies; and may it not as well prevent the accession of heat in the body, as transport it therefrom?

Again; in the following experiments, life could not have been continued, had there been no moisture, which, by its exhalation, transported the heat from the body; and had the body been immersed in water, within one or two degrees of the boiling point, as in these instances, the flesh must have been boiled, and life inevitably extinguished!

"Dr. Solander stood in a room heated to 210 degrees for three minutes, during which time, the quicksilver in the thermometer sunk to 196 degrees." "Mr. Banks remained seven minutes in the heat of 211 degrees, in which time the quicksilver had sunk to 198 degrees." "The heat of their bodies in these experiments, rose very little above its usual state." It is further observed—"From these experiments, it is concluded that no attrition, fermentation, or whatever else the mechanical or chymical physicians have devised, can explain a power capable of producing or destroying heat." (See Quincy's Lexicon Improved, under the word Heat.)

It appears, in the above experiments, that the diminution of heat in the room, was greater than its increase in the bodies, which seems to indicate a power in the body of generating cold.—Yet the body has not power to generate heat or fire; but the laws of the animal economy are empowered, slowly to decompound the substance of the body, by which operation, heat or fire is continually evolved; hence the body is supplied with animal heat.

And it appears equally true, that the body has not the power to generate cold. But if it has the power to resist the accession of

heat, it amounts, in this case, to the same thing; for the matter of cold and heat always repel each other.

But if the body has an inherent power to generate or supply cold, without deriving it *ab extra*, then the matter of cold must be an element, and a component part of some, if not all parts of the body.

That the matter of cold is a component part of the composition of ice, we have incontestible proof: and is it not equally probable it may be a component part of most, if not all compound substances; where, being combined with many other matters, it may remain much more permanent than in ice? for it is confidently asserted, that the mixture of many substances, which separately bear the operation of heat to a great degree, will cause water to congeal to ice in the heat of summer; which, if true, must be performed by the power that such admixed substances possess, to disunite the matter of cold from the others, with which it is combined; which matter of cold is always ready to associate with and congeal water.

All of which, as seems to have been the design of the foregoing experiments, proves the entity of cold.

The appearance of sparks of fire, by a fall or stroke on the head, and more especially the eye, I have formerly viewed as a total deception: so also, the glowing brightness of the eyes, which dogs, cats and many other animals seem to possess the power of exhibiting at pleasure; which in the most obscure darkness appear like balls of fire; I considered imaginary, or unaccountable; but upon mature deliberation, it evidently appears to be real fire or light.

For whatever part is finished to the highest degree of sensibility and perfection, can suffer no change, without a decomposition of some part of its substance—such is that exquisite organ, the eye, which is formed to be susceptible of the delicate operation of the rays of light only, and whose solid and fluid parts can suffer no change without decompounding some portion of them.

And for the greater perfection of performing vision, it is within the contractible power of muscular fibres, by which the retina is dilated or contracted, for the purpose of accommodating itself to the number or quantity of the rays of light, which are reflected to it.

Which fibres, when by fear or anger the nervous power is excited to the highest

pitch, so compress the eye, that some parts of that finished organ is instantly decompounded, and consequently the caloric or materia solis is evolved.

The peculiar construction of the eye, formed for the purpose of receiving the rays of light, is also calculated to emit them; by which means, whatever rays are evolved must be projected directly forward from the eye, and will be sufficient, in the darkest place, to communicate the appearance of fire.

NOTE.

While examining the proof-ſheet, it is diſcovered to be erroneous to ſay, (as in the 191ſt page) "it is only diſſipated in every direction"—for there is exhaled with the ſmoke, a portion of hydrogenous gas, which poſitively burns, and adds to the quantity of heat projected in all directions from the fire.

APPENDIX.

AFTER the foregoing ſheets had gone to preſs, the writer, by reflecting on the operation of external objects and matters, on the organs of ſenſation, and the conſequent operations upon, and the effects of the ſenſorium thereby produced, has acquired many ideas entirely new to himſelf, as he thinks they may be to others.

The operations of the mind, in performing memory, and reflection or reaſoning, has been hitherto conſidered too obſcure for inveſtigation. The ſeemingly impenetrable darkneſs of the ſubject, has led to the error, that thoſe operations were performed by that which is not material, which is next at leaſt, to ſaying, by that which has no exiſtence.

To ſuppoſe that any created exiſtence, has not parts by which it operates, appears abſurd; for if it has neither the parts nor properties of material ſubſtance, it cannot be ſaid to be nearer one thing or place than another; and the volitions of ſuch a mind will be as likely to move the

muſcles of one body, as another. Indeed, it would be too abſurd to ſuppoſe, that an immaterial ſoul, ſpirit, or mind, let its volitions be what they may, can operate on corporeal ſubſtance, by any law of nature whatever.

How the Supreme Being operates, and what is the eſſence of an unſearchable God, belongs not to mortals to enquire.

Nor has the proceſs of viſion been much leſs obſcure. It has been conſidered, by the firſt of philoſophers, that viſion is performed by the rays of light painting the image of the object on the retina of the eye; which muſt certainly have originated from not having happened to think of ſome thing more ſpecious.

What effect can an image, painted on the retina, have on the mind? Will the image vary in ſize, exactly according to the ſubſtance, which it repreſents? Will the colour of the ſhadow in the eye agree with its ſubſtance? And if it agree exactly in all reſpects; and if it is the ſhadow or image of ſolid or fluid ſubſtances, or of fire? what effect can an image or ſhadow painted on the retina have on the mind? Can it be more affected thereby than by a ſhadow on the wall, when the eye is ſhut,

and the ſhade of the ſhadow is not painted on the eye? For the mind to be affected by an image on the retina, there muſt be another internal eye, or ſome other organ, and alſo ſome kind of medium between the image or ſhadow, and the laſt mentioned organ; for without, it cannot be ſenſibly affected; from which effect the mind muſt receive the information. But this all ſeems a round-about way, by no means agreeing with the ſimplicity of the operations of the laws of nature.

In explaining the operation of hearing, an error ſomewhat ſimilar has been admitted: Becauſe the undulations of air, operate on the mind, through the medium of the ear, by what is called ſound; and the undulations being in ſome inſtances moderate, and becauſe the more the noiſe or ſound, the more the effect; and a drum being a very noiſy inſtrument, it has been underſtood that the timpanum or drum of the ear being ſituate near the ſoul or mind, operates like a drum to increaſe the ſound; hence its name.

But when we view the matter correctly, and conſider that ſenſation is the effect of ſtimuli or irritation, moving ſenſibility, i. e. it is from the touch of ſomething, which, when applied, is felt, or, by its di-

rect operation is made manifeſt (through the medium of the ſame organ, or part, to which it is applied) to the ſenſorium. And the operation is the ſame in all the organs of the body, which differ only in acuteneſs of ſenſibility, and ſtructure of parts; ſome being formed to receive impreſſions from, and feel the operations of certain things which cannot be brought to operate on other organs.

The undulations of air cannot paſs through the membranes and humours of the eye; nor can the rays of light paſs in any regular way, or in ſufficient quantities to the tympanum, to be felt thereby; neither are the papillæ of the tongue, nor the membrane of the noſe ſufficiently ſenſible, to feel the undulations of air, or the rays; neither can the papillæ of the tongue feel the effluvia of a roſe, or other matters which float in air. Nor can the olfactory nerves ſpread upon the membrane that lines the noſtrils bear the roughneſs of food; nor can effluvia operate on the retina, or tympanum; neither can common groſs ſubſtances operate on, or be felt by, any of the foregoing in their organical offices.

When the foregoing operations are viewed in their plain and ſimple order, agreebly to nature, all myſtery vaniſhes.

It is not uncommon for the greateſt naturaliſts when attempting to inveſtigate obſcure phenomena to overlook the mark, and ſearch for truths far beyond where it might be found; the event of which is, the truth is not diſcovered; but the invention of a number of ingenious hypotheſes, produce a ſpecious appearance of truth, which are received ſatisfactorily by thoſe inquirers for truth, who take their knowledge moſtly from the writings of others, without making any further ſearch concerning ſuch ſubjects. It is preſumed, that if the doctrine of irritation and ſenſibility could be ſcientifically purſued, it would lead to the diſcovery of important truths. Let us firſt enquire what are the effects of irritation on ſenſibility; or, in other words, how is the operation of memory, reflection or reaſoning, and deciſion or judgment performed?

The effect of irritation, on a part ſuſceptible of its operation, is motion. The particular kind, or manner of the motion, whether concuſſion, contraction or vibration, is very difficult, if not impoſſible to be aſcertained. Nor is it of any importance to us to know. Poſſibly in ſome caſes one, and in ſome another, and they may be ſometimes compounded; be that as it may, it will be convenient to ex-

preſs it by the term vibration. It ſeems that when a nerve is irritated at its extremity, it vibrates with the rapidity of thought its whole length. But clearly to comprehend the matter, it appears neceſſary to have ſome ideas of the nervous ſyſtem.

The number of nerves is ſaid to be forty pairs; ten ariſing from the brain within the head, and thirty pairs from the medulla ſpinalis, or pith of the back bone. It is ſaid there is alſo another pair, which paſs from the head, on each ſide of the back bone.

Although the nerves are comparatively ſmall, yet, they are divided into innumerable ſmall fibres; for there is not an artery, vein or muſcle, but which is accompanied with a nerve; and probably not a fibre without a twig of one: nor is there any part, (the ſolid ſubſtance of the bones, the nails, and hair excepted,) without nerves. They are the life-cords, and the cords of ſenſation. Through them all ſenſe is collected, at the ſenſorium; and by them all memory, reflection or reaſoning, and deciſion or judgment is performed. For the union or concentration of all the nerves compoſes the ſenſorium, which is ſuppoſed to be in the head; and which

muſt be the centre of ſenſation, whether denominated ſoul or mind; which, with al its branches, conſtitutes the corporeal nervous ſyſtem; to every fibre of which, whether in the ſenſorium or its branches, is annexed an immaterial law of ſenſibility.

This law of nature completes the nervous ſyſtem: Yet, notwithſtanding its importance, ſeems hitherto not to have been noticed That there is ſenſibility in the ſyſtem, will not be denied; but that it exiſts in a law of nature, may be doubted by ſome. That it exiſts in a law, rule or order, ſeems evident from this; that matter cannot feel, or have ſenſibility: neither can matter attract or repel; but matter may have had an invariable law annexed to it at creation; or can have a law of attraction communicated to it, as the artificial magnet has from the natural by touching. And ſteel or iron may be made to poſſeſs ſuch law by friction, or by a particular manner of putting divers pieces together, and welding, working, &c. And it is confidently aſſerted, that a bar of iron ſuſpended by one end, will acquire a law of attraction; which will become manifeſt after ſome years continuance in that poſition, by the lower end that is at liberty, inclining to the north; to a degree that puts the operation out of all diſpute. So

alfo the particles of water poffefs a law of repulfion toward each other.

But in all the above cafes, attraction or repulfion are not properties of matter, but properties repugnant to it; for it is innately inert, dead, and unoperative. But by certain figure, combination or modification, may become a centre for fuch law; which, when annexed thereto, may operate from or within it. Is it not then abfurd, to fuppofe that inert matter can feel of itfelf, or in any form have fenfibility? And is it hard to conceive, that in fome certain form, ftate or modification, it can become the centre of a law of fenfibility, which may in fuch ftate be thereto annexed? Which law may further depend upon fome particular operation of the matter conftituting its centre or refidence to excite it to operation; upon the fufpenfion of which operation, the law of fenfibility may alfo be fufpended.

That the nerves are the only centre or matter to which the law of fenfibility is annexed, is evident from this, that no kind or degree of fenfibility can be difcovered in any other matter, or combination of matter whatever. And when the trunk of a nerve, extending from the fenforium to any limb is tied, cut, or otherwife deftroy-

ed, all motion in that limb ceafes; and all fenfibility or feeling is fo entirely loft, that if hid from the eyes, the limb might be burned off without pain, or the perfon knowing any thing of the matter.

That the law of fenfibility depends upon fome particular operation or ftate of the matter conftituting its centre, to excite it to operation, is evident from this, that the law of fenfibility, in any one nerve, does not operate at all times; but for the moft part is fufpended, and that no matter or thing, fo long as its form and mode of exiftence remains identically the fame, can poffibly have a different effect, or caufe any different operation of any other matter whatever: Therefore, there muft, without doubt, be an alteration in the form or manner of exiftence of the nerves, to enable them to excite the law of fenfibility to operation. But, becaufe alteration of form requires motion in the component parts of any fubftance to produce it, which muft require more time to effect, than fimply to produce motion, it feems it muft be the effect of motion; the particular kind of which is immaterial; but vibratory or tremulous feems moft probable.

That the law of fenfibility is excited by motion of the nerves, appears evident may

ny ways—for life itſelf appears to exiſt in motion; and the operation of exciting powers externally applied to the nerves, as well as thoſe within, are ſuch that we muſt reaſonably expect will produce motion. And when from compreſſion of a nerve, that is diſtributed upon a limb, or the limb is ſuffered ſo long to reſt, that the nerves have loſt their mobility, it becomes numb, ſenſeleſs, and motionleſs; but by ſtirring, rubbing, &c. the nerves are reſtored to a ſtate capable of motion; but if the inaction has become more permanent; powerful, and rough operations are neceſſary to reſtore the nerves to a moveable ſtate.

It is common for anatomiſts, from obſerving the connections and dependences of the component parts of the body, to inform us of the uſe of the ſeveral parts thereof; which has been done with great judgment and propriety. And it may without a doubt be ſaid, that the uſe of the whole body, except the nerves, is for the ſupport, nouriſhment, defence, and ſyſtematical ſtructure of the fabrick of the nerves. For the nervous ſyſtem conſtitutes the Man, and is alone (when ſupported as above) ſufficient for all the exigencies of animal life; and does perform all matters, things, and purpoſes thereof.

That there is ſenſibility we know; that it muſt have a centre from which it operates, and a ſource from whence derived, are equally certain. But the difficulty of perceiving, and underſtanding the mode of its operation, may equally preſent itſelf to view, as an objection to all propoſitions, offered to explain its eſſence, reſidence, and derivation.

Is it eaſier to conceive that ſteel can poſſeſs a law, whereby it can attract other ſteel, without coming in contact with it, and without chains, cords, or any other matter ſerving as a medium of operations, and that at conſiderable diſtance, (and who can tell the diſtance to which polar attraction operates,) and with no ſmall power, than to conceive that the nerves may poſſeſs a law of ſenſibility, by which they may become ſuſceptible of the irritating power of whatever matters are applied to, or come in contact with them?

Can it then be denied, that ſenſibility exiſts in a law of nature; that it reſides in the nerves; and not unlike all other laws of nature, is ſolely, and continually dependent on, and derived from the great author of all exiſtence?

This law perfects the nervous ſyſtem; which, by its union, is finiſhed for all the purpoſes of the animal body.

It appears, that from the higheſt pitch of perfection in the nervous ſyſtem, (and that is poſſeſſed by man) there is a deſcent, by regular degrees, to the loweſt or moſt ſtupid ſpecies of animals; for there are nations, one of which is the Hottentots, that ſeem to poſſeſs rational powers but in a ſmall degree above the moſt ſagacious and rational of the brute creation: Among which, there are ſome that appear to poſſeſs animal life, but one degree above the vegetable creation.

The only difference there is between the loweſt degree of the animal, and the moſt active of the vegetable kingdoms, is, that in the animal, the nervous ſyſtem in the very loweſt order, conſtitutes at leaſt, ſome degree of memory and reflection. But in the vegetable motion is performed by the contractile power of their muſcular fibres, by which their leaves and flowers are folded together, which appear in ſeveral kinds, denominated ſenſitive plants, which when touched, do in a ſurpriſing manner, thus fold their leaves and flowers as if for ſafety; but when left to themſelves, ſoon again, by the ſpontaneous relaxation of

thofe mufcular fibres, rife and fpread themfelves in full luftre. But this all does not prove that fuch plants have mental powers; i. e. memory or reflection; but only, that their mufcular fibres have a contractile power, fufceptible of excitement, by irritation externally applied. And although by their motions, we can difcover but a fhort ftep from the animal to the vegetable kingdom; yet, it is in reality very great: for the animal has a nervous fyftem which is wanting in the vegetable, and it is that, by which the two are to be diftinguifhed.

The nervous fyftem, feems to be "a wheel, within a wheel;" the animal body might have been produced by the laws of nature, with its figure and all its parts, except the nerves complete without it, fixed like a tree to one fpot; but it would then have been only a vegetable.

The aforefaid law of fenfibility, is of the utmoft importance, in every point of view, relative to the operations of the animal body. By its effects, do the medium of all conveyances, communicate the fenfation of external objects, to the fenforium; and by its power, does the fenforium perform all its operations; in it, does all fenfation, or feeling, of pleafure or pain exift:

for they are both produced by irritation. But what effect can an irritating power have, without ſenſibility? The foregoing, corporeal nervous ſyſtem, finiſhed, by having the immaterial law of ſenſibility thereto annexed; conſtitutes the animal ſoul, which is common to all animals: for the moſt ſtupid reptile, is not utterly deſtitute of ſome degree of memory, &c. but it is next to nothing; as, in the firſt motions of life, diſcoverable in an incubate egg, broken when warm from under the hen, in which the firſt innate motion, though ever ſo ſmall, is the beginning of animal life; with which memory begins: and as reflection, is the recollection, comparing, &c. of what has been impreſſed on he ſenſorium it quickly follows, at leaſt, as ſoon as the ſenſorium has become ſufficiently perfected for the purpoſe. But, as before obſerved, thoſe operations are but one remove from nothing; but the lowneſs of the degree, is no argument againſt their exiſtence.

But the animal ſoul grows and decays with the body: therefore, as the animal proceeds towards maturity, the animal ſoul alſo becomes more perfect; and by habit is ſtill much more matured. Which agrees with every day's obſervation, as well as the decaying of the animal ſoul,

with that of the body: for when ſuddenly reduced by ſickneſs, a perſon of mature age becomes a mere infant, as to powers of the mind.

Alſo, in old age, a perſon becomes as deſtitute of mental powers, as an infant; ſo that if no diſeaſe or violence puts a period to life, but it ceaſes by wear and decay of time only; the powers of the body and animal ſoul, both decreaſe as gradually as they increaſed in infancy, until at laſt both become extinct at once.

It is the animal ſoul, that diſtinguiſhes the animal from the vegetable kingdom, and it anſwers all the purpoſes of animal life, both in the human and brutal creations; both equally exhibiting evidences of its poſſeſſion, except in degree of ſtrength. The evidence of memory, reflection, &c. and of dreaming, manifeſted by many brute animals, are too much within the obſervation of every one, to require notice; all which are the effects of the animal ſoul.

But, it is the conſcious ſoul, which neither grows nor decays with the body, (but is the gift of God, to man,) that judges of moral good and evil; and is the monitor within, which never fails, when at-

tended to, of guiding us in the difcharge of every duty, and which diftinguifhes the human, from the brutal creation. But, we know nothing concerning the union of the moral foul with the body; nor of its mode of operation: and being thus beyond the power of human comprehenfion, it is by no means a fubject of philofophical inveftigation.

Notwithftanding the nervous fyftem is the completion of the animal, yet it is not independent of the other parts of the body; the bones are requifite to give extention and tone to the nerves; and the flefhy parts, ferve as a vehicle f r the nerves, as well as to nourifh and fupply defects, caufed by wear from natural operations. It was therefore neceffary, the whole frame fhould have the perfect organization it poffeffes; that the whole might be propagated, and continued to perform the defigns of creation; yet, without the nervous fyftem, the body would have been but a vegetable.

With fuch organization and operations of and within the animal body, as the foregoing theory prefents to view, (which if they are not, it is prefumed are capable of being fubftantiated by found reafoning,) many matters otherwife difficult to account

for, and ſome altogether unaccountable on any other principles, become eaſy to inveſtigate.

By the aid of the foregoing, it is eaſy to decide in what life conſiſts, and what is a ſtate of death.

What is a ſtate of ſleep, and what of waking.

In what pleaſure and pain conſiſt.

The operations and effects of ſome medicines, and poiſons.

And the otherwiſe inexplicable phenomena, in many nervous affections. Some inquiries, and reflections concerning theſe, may more properly come in ſubſequently.

It ſeems proper in the next place to conſider, how the animal ſoul, completed by the union of the law of ſenſibility, performs all the operations neceſſary to fulfil the purpoſes of the animal economy. It was ſaid early in this part of the work, that the effect of irritation, on a part ſuſceptible of its operation, muſt be motion. It appears that the laws of gravitation, attraction and repulſion, operate inceſſantly: although they may in ſome inſtances, be

overpowered for a time. But it appears, that to perfect the operations of the animal economy, innumerable viciſſitudes of action and ſuſpenſion, are indiſpenſably neceſſary; and it is reaſonable to ſuppoſe, that the laws deſigned to govern the ſteady courſe of nature in the univerſe, ſhould be conſtituted, to perform the operations neceſſarily connected with their offices. And that a law, deſigned to perfect the animal ſyſtem, ſhould be differently conſtituted; ſo as to fulfil the perpetual changes, neceſſary in the animal economy.

But the law of ſenſibility, cannot be ſuppoſed, to cauſe itſelf to operate when neceſſary, and be ſuſpended when not needed. Some other ſource, therefore, muſt be found, that has power to excite, increaſe, diminiſh or ſuſpend its operations; or, if conſidered as operating by excitement only, (which is doubtleſs correct,) it is enough, that it has power to excite when neceſſary.

And it ſeems the ſources of excitement are numerous, and extremely extenſive—that all things, which operate on the external organs of the body, are exciting powers on the law of ſenſibility; ſo are all reflections, and deciſions or volitions, of the mind within.

So alſo is the power of the creator, in thoſe operations, which are termed inſtinctive actions All which, operate by cauſing a vibratory motion of the nerves, when thereto applied—which, if it begins at the external extremities of the nerves, the vibration is continued along the nerves, to the ſenſorium. Which motion, wherever it is produced, always excites the law of ſenſibility to operation.

And alſo, that all memory, reflection, and deciſion or volition, are performed by vibratory motions of the nerves, where they are concentrated; i. e. at the ſenſorium; by which vibrations the law of ſenſibility is excited, and continued as long as the vibratory motion remains.

And likewiſe, that the ſenſorium does excite the origin of the nerves, whoſe extremities are eventually ſpread upon the fibres of the muſcles, to the ſame vibratory motion; which is thereby communicated to the muſcles, whereby the law of contraction, or the contractile power thereof, is excited, and muſcular motion performed.

The newneſs, intricacy, and obſcureneſs of the ſubject, renders it not only difficult to form correct ideas of the matter, but

extremely difficult to communicate them ſo as to be underſtood, without more repetion than otherwiſe would be agreeable.

An attempt will now be made, to follow the operation of excitement, on the law of ſenſibility, through the nervous ſyſtem, to the final effect thereby produced.

Suppoſe an object, for inſtance, a fair face, placed in a ſituation to reflect the rays of light to one's eye—the irritation of thoſe rays, will be felt by the extremities of the optick nerve, ſpread on the retina; whereby a vibratory motion will be produced, and the law of ſenſibility thereto annexed, will be excited to operation, which vibratory motion, and excited ſenſibility, will be inſtantly conveyed along the nerve, and communicated to the sensorium, and the sensorium having acquired by habit, the knowledge that there are a great variety of figures, by which light is reflected; and having also by habit, acquired the power to examine objects by moving the eye in its ſocket, and turning the head on its atlaſs; does for that purpoſe, excite vibrations at the origin of the nerves, whoſe extremities are ſpent on the muſcles, which actuate the eye-balls, &c. and by the acuteneſs of thoſe organs, feels almoſt exactly the diſtance the eye-balls

or head have moved in every direction, to furvey the object by which the sensorium acquires, the almost exact figure, dimenfions and fymmetry of the face, all which are continued in vigorous operation, so long as the rays of light, which are the moving power. continue to operate; and which vibratory motion is afterwards continued by the power the sensorium possesses, to continue the law of fenfibility in operation, but which is by no means so lively in the mind, as when continued by the power of the moving caufe; it being only the continuance or remembrance of what is paft, which, however continues in a faint degree, until some other irritation from without, or reflection within, directs the emotions of the fenforium another way; when thefe emotions ceafe, and we fay the matter is forgotten, but in general is not finally loft; efpecially when the operation has been long continued, or often repeated; by which the operations have become habitual, and readily excited by reflections within the fenforium, or by other vibrations nearly connected with them, although excited by other powers. For the excitement caufed by the rays of light, are accompanied by, and nearly affociated with others, received through various organs at the fame time; for undulations may be caufed by the tongue of the

ſame perſon, and operate through the medium of the ear, by which the ſame vibrations may be renewed, which were excited through the medium of the eye; although the face is not ſeen; or through the medium of any of the organs of feeling, in any part of the body, and any other objects ſeen or heard, &c. near to, and at the ſame time with the former, may have an operation; any of which operating afterward, may inſtantly excite the former to operation; i. e. bring them to mind or remembrance.

It is within the obſervation of every one, when getting a ſong, hymn, or other compoſition by rote, that to remember the form of the words, the letters, and their ſhapes, helps to recollect the chain of words to be remembered. Likewiſe, when there is only ſenſibility remaining in the ſenſorium, that ſomething is to be done or performed, although every other operation concerning the matter has ceaſed; i. e. although the remembrance is loſt. By ſeeing, hearing, or otherwiſe being informed, through any of the organs, of ſome other matters which excite vibration and conſequent ſenſibility in the nerves next adjacent to, or connected with, thoſe whoſe vibrations, &c. had, as above, been ſuſ-

pended, they will inſtantly vibrate again; i. e. the matter will be recollected.

Alſo, when one wiſhes to recollect a tune, which has been perfectly committed to memory, or in other words, vibrating motions, and conſequent ſenſibility excited thereby, have been ſo often repeated, that the repetition has become habitual, but is now ſuſpended; that when the vibrations, which had been produced by the words ſung with the tune, are again excited, which is recollecting the words, that every emotion, with the intire ſenſibility of the tune, at once takes place; and the perſon is then ſaid perfectly to recollect the tune.

Alſo, when one repeats a long leſſon, learned by heart, that there is not the vibrations and ſenſibility of the whole at once in operation, but of perhaps one ſentence, or part of a ſentence only, as repeated; but that from habit, the vibrations of the preceding ſentence excite thoſe of the ſucceeding one; for when the whole are entirely ſuſpended, exciting the vibrations produced by hearing the firſt word, the next will be thereby produced, and the whole move on in ſucceſſion without delay. From all which it ſeems clear, that memory is performed by, and exiſts in, a vibratory motion of the nervous ſyſtem;

and that principally at its concentration, which constitutes the sensorium; whereby the law of sensibility, which is annexed to it is excited, and continued in operation, as long as the vibrations, on which its operation depends, continue, and no longer.

Reflection, (reasoning) is the effect of memory. We reason from what we know; and our knowledge is neither more nor less than what we remember.

There is no small difference in mankind, respecting the power of the sensorium, in comparing what they do retain in memory; and making deductions therefrom. It seems to be generally considered, that a retentive memory, is the most useful quality of the mind. And it is true, that all knowledge exists in memory. But if one could retain in memory, all the occurrences, that ever came to mind, and was destitute of the power of comparing the past, that occurred at different times, and also the past with the present; thereby drawing inferences from the reflections. Such memory would prove of little use.

It is a powerful, quick, and penetrating faculty of reflecting and reasoning, that above all other things, constitutes great powers of mind.

It appears from obſervation. that a retentive memory, and the power of deep reaſoning, are rarely conjoined; it is doubtleſs very happy when they are. I have ſeen an inſtance of one, who poſſeſſed the moſt extraordinary power of retaining, and of repeating whatever came within his obſervation ; yet was ſo deſtitute of the power of reflection, as to be incapable of procuring for himſelf a ſubſiſtence ; and was ſupported by the town ; he was not in the leaſt deranged.

Wiſhing to place this matter in as plain a point of view as poſſible, and believing that the hiſtorical account of a certain tranſaction, may prove the eaſieſt, moſt familiar, explicit, and conciſe way, to explain the mode of operation, of the ſenſorium, in performing reflection, &c. is thought ſufficient apology for introducing the following anecdote.

A certain man had determined to perform a journey ; the place of deſtination was fifty miles due South, from his reſidence. He inſtantly began to ponder and reflect upon a plan of operation, ſuited to all his exigencies, in the accompliſhment thereof ; the nerves compoſing the ſenſorium, ever buſy and ready to aſſiſt on ſuch occaſions, one after another ſprung into

action; and excited the law of ſenſibility, with them connected; concerning many matters that had heretofore excited the ſame operations in them, but which, until now, had remained moſtly dormant. Of the danger and trouble of paſſing a broad, dreary, gloomy, and trackleſs foreſt. And alſo, of the fatigue, expenſe, and loſs of time, inſeparable from travelling a much greater diſtance, for the purpoſe of being accommodated with a good road, &c. Or in other words, in this, as in all ſimilar caſes, impreſſions of matters of importance, as well as thoſe of leſs conſequence, which have been produced by the power of excitement, by light, through the medium of the eye, when travelling on the road at different times, and alſo thoſe made by the power of exeitement, from undulations of air through the medium of the ear, moved by the tongues of thoſe, who repeat the facts at different periods, had for the moſt part until now, ſubſided; ſuch impreſſions or dormant vibrations, and excited ſenſibility, leap as it were ſpontaneouſly into action. So in this caſe, the man becomes engaged in forming his plan: the active and buſy nerves voluntarily vibrate, and rouſe to action the ſleeping law of ſenſibility, with them connected. A full view of the road, with all matters and circumſtances attending the ſame, appear plain to his mind;

he ſaw a diſtance of fifty miles due Weſt, would bring him to an angle in the road, to which, when he ſhould arrive, although he would then have travelled as great a diſtance as would, if he had croſſed the foreſt, have completed his journey ; yet, when there, he would be twice as far from its end, as when at home.

Again, the faithful nerves quickly preſent his mind with a view of the road. and all attendant circumſtances, fifty miles due South ; and alſo, that although he would when at the end thereof, have travelled twice as far, as from his reſidence, to the place of his deſtination ; yet here he would be no nearer than when at home.

Again, recollection preſents to his view, a road extending fifty miles due Eaſt ; which will bring him to the place of his deſtination. Here the mind reſts a while, contemplating a variety of real matters and circumſtances, together with many preſented by imagination, that have not had, nor ever will have existence. From hence the mind traverſed back the rout, and reviewed all matters and circumſtances connected with it.

Nor does ſenſibility reſt at the minds return, but preſents to view, the paſſage acroſs

the foreſt; the dangers from wild beaſts, from inclemencies of weather, and from becoming bewildered, or loſt, when attempting to purſue his courſe.

While reflecting on the foregoing, many other ſubjects preſented themſelves for conſideration; protection from inclemences of the weather, whether ſtorms or cold; cheering ſpirits; agreeable travelling; and comfortable lodgings, afforded by hoſpitable inns on the road, were pleaſing reflections. But he recollected they coſt money; and alſo, that money was not to be attained without fatigue and labour. Memory alſo informed him, that a ſufficient ſtore of hearty food, and high ſpirits, for a ſhort journey, although not ſo pleaſing, would not be a tedious burthen to travel with; that fatigue cauſes a ſharp appetite; and that "to the hungry ſoul, every morſel is ſweet."

All the foregoing, and many others, were, by the power of recollection, preſented at one view, or followed each other in ſuch quick ſucceſſion, that no intervening ſpace was perceptible. Thus ſupplied with materials for reflection; a field of which, were now at once preſented to his view: He pondered, conſidered, reconſidered, and reflected; comparing the advan-

tages in one route, with thoſe in the other; and alſo, the diſadvantages in the one, with the ſame in the other. From ſuch compariſons, drawing inferences, and by comparing probable events, and occurrencies in each, with the other, and having taken ſufficient time to mature his deliberations, as a wiſe and prudent man, will in all caſes of importance do; he at length decided in favour of croſſing the foreſt; i. e. he formed a judgment, that it was moſt for his intereſt, and beſt for him, to journey that way.

And; as the purſuit of mankind is happineſs, when it is decided in the mind, that any certain matter or manner of procedure is beſt, it is thereupon the decided choice: Hence, deciſion or judgment, and willing or volition are one, and the ſame.

Such is the conſtruction of the animal machine, that the deciſions of the ſenſorium, or volitions of the mind, in all inſtances, govern the muſcles, which move the body So in this caſe, the choſen time being come, the mind willed the movement of the body; i. e. the ſenſorium excited vibrations in the nerves, diſtributed to the fibres of the muſcles which move the body; and the man is thereby on his way.

By attending to the particulars of the foregoing relation, the meaneſt capacity can underſtand the operations. changes, and movements that take place in the animal body, in performing memory, reflection, and deciſion.

It appears, there are but few people, who have any knowledge how themſelves proceed in forming a judgment; that when compelled to decide, they proceed with uncertainty, and without knowing what they ought to do; but they ſhould know that in forming a judgment in all matters of importance, they are to be actuated by what they know only; and not by what they ſuppoſe or believe; and not by reflecting on a part of what they know, but the whole: Deliberately conſidering every minutia connected with the ſubject.

If ſuch were the practiſe of thoſe who judge law-ſuits, we ſhould doubtleſs, have leſs erroneous judgments, from thoſe who are unlearned, and inexperienced.

If farmers, mechanicks, and traders would ſtrictly attend to the above rule, they would meet with leſs diſappointments in buſineſs.

That connection which subsists through the course of the modus opperandi, of the animal or natural soul, when performing its various offices, which in great measure, are a continuance of the same chain of operations, of which muscular motion seems the last link; rendered it difficult, when treating of memory, reflection, &c. to avoid making some observations concerning muscular motion; but which, in the next place, requires more particular attention.

MUSCULAR MOTION, has commonly been ascribed to an influx of nervous fluid; and by some, of the arterial blood also, into the muscular fibres; which, when mixed therein, by a sudden fermentation, causes the muscles to swell; by which, they are shortened in length: Others have ascribed the operation to the influx of nervous fluid only. But these hypotheses, have not satisfied all.

But, admitting there is such a thing as nervous fluid, or animal spirits, which seems altogether doubtful; for the nerves are little larger than hairs; and although arteries may be discerned in them, by the help of a microscope, yet, no passage for

the nervous fluid, could ever be difcovered. But it is admitted, that is not conclufive proof, that they are not tubes; and that there is not a paffage in them for fuch fluid. But it feems conclufive proof, that thofe fmall cords (with no difcernable paffage for its conveyance,) cannot difcharge a fufficient quantity of that fluid, to fwell the large mufcle, forming the calf of the leg. So, that it may inftantaneoufly bring the heel in contact with the thigh. Nor is it to be fuppofed, that the whole quantity contained in all the nerves in the body, and alfo in the ventricles of the brain, is fufficient for that purpofe. Neither does it appear well calculated to convey fenfation, as it has been commonly fuppofed to do; for it is hard to conceive, that any thing fo grofs, as a real liquid, can pafs in fuch tubes, with the rapidity of fenfation; indeed, the matter appears abfolutely incredible. If it cannot caufe the contraction of the mufcles; and is not the medium of fenfation; alfo, if it cannot be difcerned nor the paffage in which it is fuppofed to move; which laft are facts: There appears no ufe for fuch a fluid, nor any reafon why we fhould not doubt of its exiftence.

But if the idea of a nervous fluid, muft be retained, it ought not to be fuppofed a

grofs liquid, but a rare fine fluid; so fubtile, that without any cavity for the purpofe, it may pafs, with the velocity of lightning, in the interftices, between the corpufcles compofing the nervous cords, in the fame manner as electric fluid does, through a conductor of metallic wire.

Thus confidered, it appears not an inconvenient mode of conveying impreffions from the fenforium to the extremities of the nerves. But, to anfwer the purpofe of conveying impreffions from the furface of the body, to the centre of fenfation, there muft be an accumulation of animal fpirits, at the extremity of every nerve, always ready to perform that office, which is altogether inconfiftent with the fimplicity of nature; it appears much more fimple and agreeable with the ufual operations of nature, to fuppofe that the touch of external objects, to the extremities of the nerves, fhould produce a vibratory, or tremulous motion, that may be inftantly communicated to the fenforium; and fo fine a fluid, is alfo incapable of diftending the bellies of the mufcles, and thereby producing mufcular motion.

The illuftrious Baron HALLER, who was the moft accurate anatomift and intelligent phyfiologift of the age, has demonftrated,

that the arteries contribute nothing to muſcular motion, but so far as they nouriſh and preſerve the natural ſtate of the parts. Conſidering the high authority of Baron HALLER, and it being directly in point, I take the liberty to tranſcribe the following from his *Primæ Linæ Phyſiologiæ*, where he ſays, "The direct manner, by which the nerves excite motion in the muſcles, is so obſcure, that we may almoſt deſpair of ever being able to aſcertain it. As to the nervous vesicles ſwelling by a quicker influx of the nervous ſpirits, it is inconſiſtent with anatomical truth, which demonſtrates the leaſt viſible fibres to be cylindrical, and in no part veſicular, and is likewiſe repugnant to the celerity, with which muſcular motion is performed, and with the bulk of a muſcle, being rather diminiſhed during its action Again, the inflation of the rhomboidal chains in the fibres, is equally repugnant, both to that celerity, and to the evidence of anatomy. Finally, it is by no means demonſtrable, that the fibres from ſo few nerves, can be so numerous, or diſtributed in ſo many different tranſverſe directions, with reſpect to the muſcular fibres, as thoſe hypotheſes require to be allowed. The notion of nerves wove round the arterial fibres, so as to contract them by their elaſticity, is founded upon a falſe ſtructure of thoſe

fibres, ſuppoſing nerves to be diſtributed where filaments of the cellular ſubſtance only can be traced. Other explanations derived from ſphericles full of air in the blood, ſuppoſe a falſe nature of that fluid, namely, a repletion of it with elaſtick air, of which it has none."

No explanation hitherto propoſed, in the leaſt agrees with the quickneſs with which the muſcles contract, and are relaxed. The dexterity of the hands of a muſician, when playing on a muſical inſtrument, by habit, becomes quicker than thoughts ſucceed one another; at leaſt when thoughts are voluntarily moved; and not of one hand only, but both at the ſame time; yet they do not excite themſelves, but are excited by the power of the animal ſoul; the performance of which, it has acquired by habit. Than which, nothing can be more in evidence of the truth of the foregoing theory. The force of facts from experience, are the moſt irreſiſtable evidence. From practice when young, the writer had acquired a habit of taking, or catching a hand ball in air. An inſtance of which, moved the admiration of a number of ſpectators. Standing near where a ball was ſtruck, with great force by a bat; the noiſe of which, attracted attention, and the eyes were turned that

way when the ball within two yards from the eyes, reflected the first rays of light to them, they were thereby irritated; the irritation was communicated to the fenforium, which excited motion in the nerves, diftributed to the mufcles of the arms, hands, &c. The mufcles were contracted, by which the arms, and hands were placed in proper form and directions, guided by the eyes, to receive and hold the ball; all which was done, while the ball, moving almoft with the fpeed of one difcharged from a gun, paffed lefs than two yards, probably not more than one; occupying a fpace of time, hardly fufficient to pronounce a fingle fyllable. Are fuch mechanical operations? Can that maxim, which in all cafes applies to mechanical operations, be applied to them? By reverfing it may; for mufcular motion is ftronger when quick, than when flow. All which, is in proof of the truth of this theory.

Can we not, and muft we not. give up the idea of explaining thofe operations, by any power, operating fimilarly to the mechanical inventions of art; and reft fatisfied with underftanding how external matters operate on the external organs; how the fenfe thereof, is communicated to the fenforium; how, and by what means, conveyed from thence to the mufcles. And

admit a law, therein to exiſt, ordained by the Creator, for the purpoſe of contracting them, &c. when thereto moved by volition, and abandon the idea of being able to explain mechanical operations, which never have, nor ever will take place in the muſcles.

If the foregoing reaſoning is concluſive, ſome other cauſe muſt be deviſed for the production of muſcular motion. There has been ſome, who, conſidering the inadmiſſibility of the doctrine, which taught that the nervous fluid produced muſcular motion, have denied its exiſtence; aſſerting that the nerves were only vibratory cords, and in that way performed their offices; which appears correct, beyond whatever had been before advanced. But whether from the obſcurity of the ſubject, or for want of leiſure, they have not purſued their reſearches to any conſiderable degree of inveſtigation, perhaps they did not begin their enquiries far enough back, to have the matter become plain to them.

It is the opinion of ſome of the firſt philoſophers, that, in the moſt compact ſolid, the real material ſubſtance, is almoſt inconceivably leſs than the vacuities, or empty interſtices, betwixt its component particles.

But, if to avoid any thing extravagant, we allow an eagle, (gold being the heavieſt of all metals.) to be one part in a thouſand, ſolid ſubſtance, and only 999 parts of empty ſpace; even, that may appear ſurpriſing to thoſe unaccuſtomed to reflecting on ſuch ſubjects; but a little attention, may poſſibly make it appear leſs aſtoniſhing.

It is an inconteſtable fact, that no particle of matter, can have leſs than ſix ſides; although it may have more, by varying its figure; for, if a perfect ſphere, it cannot have leſs than ſix points anſwering to ſix ſides. It is alſo a fact, that the fineſt corpuſcle that has two ſides, is capable of diviſion; and when divided, the ſides of the two halves, muſt amount to not leſs than twelve; which will be thus increaſed by every ſubſequent diviſion. And no one will pretend, that perpetual diviſion can annihilate; therefore, matter is diviſible, ad infinitum. (It is not intended that any finite power is capable thus to divide matter; but only, that it is capable of being ſo divided.) And all will agree, that diviſion increaſes the volume of matter; i. e. two halves will occupy more ſpace than when united in one. Hence, it has been aſſerted, that a ſmall particle is capable of diviſion until its volume, without addition

of matter, ſhall be equal in ſize, to the globe of the earth.*

It has been aſſerted, and it appears with good reaſon, that no particles of matter ever come into abſolute contact. And when

* To think, reflect, or reason correctly and philosophically, it is of the utmost importance that the mind should be entirely free from all prejudice concerning the extension, minuteness, &c of matter. The intention of this note, is, as far as possible, to extend the mind to an acquiesing belief that matter is extended beyond all finite comprehension; that its minuteness exceeds the utmost stretch of thought; and that the corpuscles contained in but a small space, are numerous beyond the utmost extent of imagination to conceive.

Notwithstanding air is not the subject under consideration in the text to which this note is subjoined, yet, it is considered a proper subject to exercise the mind upon, for the foregoing purpose.

It has been urged, that each particle of which fluids are composed, (the properties of which. are in a high degree possessed by air,) possess by authority from the great Creator, a law or power of repulsion, by which no two of them can be forced by any natural power ever to come in contact, or to touch each other. Although that law may in some measure be depressed by violence, and the particles forced nearer one another; yet they never cease resisting such violence, and soon as may be, overcome it, and take that distance assigned them by the law of nature, by whose power they are independent of each other; gliding and rolling submissive to every force, which does not encroach on their repellent and constituent law, or power; and in a collected state, form a mass, possessing all the properties of fluidity.

it is expreſſed that the particles touch or come in contact, it is to be underſtood, that the law of attraction has brought them as near together, as the univerſal law of repulſion, (which is more or leſs annexed to all matter,) will admit them to come;

We live in, and are familiar with the air; we see and are acquainted with other fluids; we are sensible the particles composing them are extremely small; but have we indulged imagination on the subject? for our senses can give us no information concerning their fineness. nor can a single particle affect any of our organs. Doubtless we have considered them fine indeed:—but let us indulge imagination.

Suppose a thousand million of the particles of air, collected in a cistern, or bladder; it is not probable, that the bladder, distended with that number, and of thickness equal to its size, would be a millionth part of the bigness of the smallest pins head; or that it could be discerned by the help of a microscope.

Yet, many of our conveniences depend upon the operation of these, collectively; (and in tornadoes they are shockingly terrible and destructive.) Nor can life itself, be continued, but for a moment, without them.

This to be sure, is carrying the imagination of the minuteness of matter, a great length; but, it falls inconceivably short of the truth, for want of discernment. To aid the imagination in its excursive pursuits, towards a concession of the fineness of matter, let us turn our attention to the vast expansion thereof; and endeavour to see, how infinitely we fall short in our ideas of greatness.

We have considered the smallness of the volume, that a thousand million of particles of air, would make; and that each particle possesses a law of repulsion, by the power of which, they are kept from

for, it is the law of attraction, that brings together, and confines the component corpuscles, in all compound ſubſtances.

But, there are a great variety of appearances in the kingdom of nature, that de-

ever touching one another. Let us now suppose a very large cistern, for if compared with one of a middling size, of those with which we are familiar, it must be large. Yet, if compared with a middling size of those in vast creation, it is uncertain, whether it would be large or small. Which cistern, is to contain a thousand millions of particles of air; each, of the size of the globe of our earth; every one of which, to possess a law of repulsion, extending its operations the same distance from the particles, that the earths atmosphere goes from it; which, suppose to be fifty miles. Which law of repulsion, as in fluids, generally, cannot be overcome; although it may suffer depression, is it not clear, that, this mass must, as well as that composed of the smaller particles, be a fluid; that those particles will dandle, and roll, and the mass ripple when agitated? And may we not suppose, that these large particles, thus composing a fluid, may be inhabited, by innumerable animal beings; for, notwithstanding, they collectively compose a fluid, yet, that irresistible law, or power of repulsion, which constitutes fluidity, must prevent them from touching, and consequently preserve the inhabitants from being crushed; indeed, it seems, they would be perfectly secure from injury, on that account. As it appears, the inhabitants of this world would be, in case a comet, with its greatest velocity, should strike full speed against our atmosphere, and depress it, half way from its summit to its base; yet, the elastick fluid would repel it, with equal velocity.

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mand the explanation of another and different law of nature, without which they are utterly inexplicable.

There are ſome inanimate ſubſtances, which become flacid, limber, or drooping

All this, the mind can have conception of, so far as the subject does not extend beyond finite comprehension. And all things are easy, with omnipotence.

The more we reflect on such subjects, the further we can extend our ideas, towards comprehending the minuteness of matter. Let a clear glass, containing good vinegar, be placed on a window, where the sun shines, and the naked eye, can discern innumerable animalcule, in shape and motion, resembling Eels. Consider, these must be organized bodies; that they must have muscles, sinews, arteries, veins, nerves, &c. that their vessels must contain circulating fluids. Reflect a moment on the smallness of the particles composing those fluids; which particles too, must be compound matter; for pure water cannot supply the place of animal fluids. These, in our view, are comparatively small; but in reality, they may be comparatively large.

Although we can form no idea of the size of a particle of air, yet, we know the great body of air is made up of parts, and that there must be particles; what reason can be assigned for doubting, that each particle of air, (or any other fluid) may serve as a dwelling place, or world, for millions of millions of animals, of infinite variety, in form and size, to inhabit? The air being agitated by winds, and even tornadoes, can be no objection; for, the violence of any agitation, can never overcome the power of repulsion, which prevents those globes from touching each other; and thereby crushing, or in any other manner injuring the inhabitants on their surfaces, Nor is their

at times, and at others. regain their natural firmness, tension and form; but, it is doubtful, whether this ever takes place, except in the preserved ſtate of animal ſubſtances; and it ſeems to be of the nerve

velocity compared with that of the earth, &c. in any measure, equal, to that, with which our globe is tossed about; or in comparison to size rolled over

It is as easy for us to conceive the manner of transacting business, among those small inhabitants, as readily, to conceive the velocity, with which this earth moves round the sun, in its annual orb. Nor is it any objection, that the motions of our earth are regular; and can be calculated beforehand by astronomers: For, the motion of theirs may be as regular, as is necessary for their convenience. Does the matter appear too hard to admit of credit? The answer is, there is nothing impossible with God.

To assist the mind, in its attempts to conceive the extreme minuteness of matter; let us again turn our attention to the contrary extreme. We have above, exercised our thoughts concerning a fluid, composed of particles of the size of our earth. Let us suppose an earth or world, in all other respects like ours: together with a sun, and solar system, starry region, &c. at proportionate distances; but the whole as much larger than ours, as the particles composing the above said fluid, are larger than those of common air; might there not be placed therein, a race of men, and all other animals equally large; who might respire, or breathe such an air, as a vital fluid, (all other things being in the same proportion,) as conveniently as we do the air, of this, our atmosphere; no one dares to set bounds to omnipotence. And when millions of millions of such systems are set forth, room to place more in boundless space, will not in the least, be lessened.

and muſcular fibres only: ſuch as cat-gut, parchment, &c. which, when violently ſtretched, poſſeſs a moſt extraordinary power of contraction, which they retain long, and do not, perhaps entirely part with, until broken, or decayed. This contractile power, can by no means be the reſult of the law of attraction; for doubtleſs the law of attraction operates more powerfully in a diamond, &c. than in a viol ſtring — Glaſs ſeems to be ſupported almoſt alone by the law of attraction, notwithſtanding it has ſome elaſticity, for when but little diſtended, its particles ſeparate. And it appears that elaſticity is in all caſes proportionate to the contractile power—the ſubſtance poſſeſſes the muſcular, or nervous fibres, taken from that part of a ſeed horſe where they poſſeſs the greateſt power of extenſion and contraction; after being dryed retain a moſt ſurpriſing contractile power, which they exhibit when diſtended; but in living animals the power of diſtenſion and contraction, is manifeſt in many parts, ſome of which, may with propriety be mentioned: i. e. all the muſcles and membranes that have muſcular fibres in their texture, and which in a Turkey Cocks Comb, is exceeding conſpicuous, and the comb is probably harder when contracted, than when diſtended; it cannot, therefore, be diſtended by an influx

of fluids only but an extenſion of its componant parts, into which more humours may flow, but without increaſing the diſtenſion, is evident from its ſoftneſs; and it would be abſurd to ſuppoſe its contraction cauſed by an influx of fluids, for that muſt rather diſtend than contract.

It is alſo aſſerted, and doubtleſs with truth, that the muſcles contract in diameter, when they contract in length, to move a limb, which is concluſive evidence that they are not ſhortened, by an influx of fluids dilating them, which has been the opinion moſt generally received.

Conſidering the vacuities in hard ſubſtances before mentioned, it is plain that in the ſofter muſcular ſubſtance, there is not ſuch plenitude as muſt prevent the particles compoſing them, from being brought nearer together, than in their natural ſituation; and that they are not ſo fixed, but they may recede further aſunder.

It ſeems neceſſary to endeavour to point out an adequate power, for the performance of muſcular motion, and explain its mode of operation.

Much has been ſaid concerning laws of nature, or rules for the operations of mat-

ter; a variety of which, are by the Creator, annexed to many matters, operating variously; but in all cases, answering the purpose for which they were intended. Several of which, have been admitted time immemorial; but those, heretofore admitted, are not sufficient to answer every requisite purpose, to perform all the operations in the kingdom of nature; some of which operations must be refered to the immediate operations of deity, or other laws admitted. The law of sensibility has been sufficiently dwelt upon; and is as necessary for the accomplishment of muscular motion, as for any other purpose, but that alone is not enough.

A law of contraction, is also necessary. For, there is not the most distant similarity in the contraction and distension of a muscle, and any kind of mechanical power, ever seen to operate by man.

The muscles, in perfect obedience to the will, instantly performs with speed, and almost inconceivable force, whatever is in their power to do: and when we consider that a person of 200 pounds weight, can, in some instances, raise himself on one leg; and have also in mind, the disadvantage from the length of the thigh bone, &c. we

cannot but be ſurpriſed at the ſtrength exerted by the muſcles and tendons.

The operation is altogether unlike any mechanical power; nor will the maxim, which never failingly applies to any of them, in the leaſt apply to this; i. e quick and weak, or ſtrong and ſlow. To exemplify this, ſuppoſe a lever ſix feet long, reſting on a prop or ſupporter ſix inches from the end, where the weight to be raiſed, is ſuſpended; the power to raiſe which, is applied at the other end, $5\frac{1}{2}$ feet from the prop. The power ſo applied, muſt deſcend 11 inches, to raiſe the weight one; in this caſe, the force is ſtrong; for a little more than one pound, will riſe 11; but ſlow, for the power muſt deſcend 11 inches, while the weight riſes but one. Reverſe the matter, and apply the weight to the end, which is $5\frac{1}{2}$ feet from the prop; and the power 6 inches from the ſame, on the other end. In this ſituation, the power, by deſcending one inch, will raiſe the weight eleven; this will be weak, but quick, compared with the motion of the power which moves it; but it will require eleven pounds of power to balance one of weight, and ſome addition to move it. And the principle is the ſame, in all kinds of mechanical powers.

It is admitted, that the animal body, in many refpects, operates mechanically; but that the extenfion and contraction of the mufcles, bears no affinity thereto. It is alfo true, that a heavy weight retards the motion, of the hand, when raifing it; but this equally applies to all motion, which is always in proportion to the refiftance that is oppofed to it, and when overcome, muft ftop.

Therefore, it muft be an inherent contractile principle, or law of contraction, which is annexed to each mufcular fibre; and which acts beyond the law of attraction; the latter atracting the particles as near together, as the law of repulfion or the defigned ftate of the part admits, when it has performed its office. But the law of contraction goes further; it compels the particles to come ftill nearer together; or, if neceffary, to fulfil its office, forces fome of the corpufcles into the empty fpaces between others. And if neceffary for diftenfion of the parts, to be carried to a degree that overcomes the law of attraction; in fuch cafe, the more extenfive law of contraction operates, a prevents and feverance of the componant particles.

This law of contraction, is moved in all its operations, by the law of fenfibility,

which, in the voluntary muſcles, in a healthy ſtate of body, is entirely under the controul of the ſenſorium. The mode of operation on which, and whoſe mode of operating have been deſcribed, when treating of memory, &c. but to which, it appears neceſſary, in this place, again briefly to advert.

It has more than once before, been obſerved, that the effect of ſtimulants applied to a part ſuſceptible of their operation, is action. Conſequently, when the rays of light ſtrike the eye, the branches of the opthalmick nerve are moved, the vibrations thereby excited, are inſtantaneouſly communicated to the ſenſorium, which continues the vibration, and propels the ſame to ſuch part, or parts, as by habit it has acquired the power of doing, and of knowing, may conduce to the ſafety, or pleaſure of the body; i. e. if the ſtimuli, producing the vibration of the nerves of the eye, denote the approach of a ſtone, to the head, with deadly effect; the power of the ſenſorium, will cauſe the nerves, which are diſtributed to the muſcles, which move the head, and other parts, inſtantly to vibrate, by which the law of contraction is excited; by which means, thoſe muſcles will be contracted, or relaxed, or, ſome one, and ſome the other, as the caſe may

require; by which, the head will be moved out of the way of danger.

It may at firſt view, appear abſurd to ſuppoſe, that a vibratory motion only, in a few very fine cords, ſhould produce all this effect; but, let it be remembered, that the whole operation, is produced in the firſt place, by the irritation only, which the eye feels, from the inconceivably ſmall rays of light ſtriking it. Which fact, if we had never experienced, no evidence could but hardly have enforced the belief upon us.

That muſcular motion at all times, in a ſtate of health, is the effect of the operation of external matters, on the organs, of the body, or reflections on ſuch as are remembered, that have come through the medium of thoſe organs; and volition, or willing, governed by thoſe operations or their remembrance, are produced by, and exiſt in vibrations of the nerves in the ſenſorium; and by the power of the ſenſorium are communicated through the medium of the nerves, to the extremities of the ſame, ſpread upon the fibres of the muſcles; are operations that ſeem not hard to underſtand; and it is believed, muſt appear more rational, than any mode hitherto propoſed. Nor does there any reaſon appear, why the vibrations of thoſe nerves ſpread upon the

muſcular fibres, ſhould not excite the law of contraction, thereto annexed to operation. The only difficulty ſeems to be, in conceiving how a law of contraction does exiſt in, and operate on, thoſe muſcular fibres, ſo as to perform muſcular motion.

Is it a harder thing to conceive, that the Almighty has eſtabliſhed a law, or power, in the muſcular fibres of animals, which is ſubject to the controul of the ſenſorium, through the medium of the nerves; which law, is fully competent to move thoſe fibres to perform all motion, neceſſary in life; and that, without operating mechanically, than it is to believe a law of attraction, annexed to the polar ſtar, or ſome other matter or thing, in the regions of the north; or that attraction, repulſion, and gravitation are performed, by immaterial laws of nature only?

The laws of nature are totally inexplicable, and we know nothing of them, but their operations only; it would ſurpriſe us, if any one ſhould undertake to explain the modus opperandi, of polar attraction; i. e. in what manner the polar ſtar manouvres to draw the point of the needle toward itſelf; or in what way the needle ſets itſelf to work, to attract the northern ſtar or region; for the attraction is mutual, al-

though the needle being lighteſt, alone ſuffers motion. If the doctrine is true, that reaſoning, &c. is performed by matter, it is concluſive proof, that immaterial exiſtence, or ſimply a power to operate, is utterly beyond its comprehenſion.

WHAT IS LIFE, AND WHAT DEATH?

It has been determined by great philoſophers, that fire exiſts in motion ; i. e. that fire is only an inteſtine motion among the particles of matter ; but this hypotheſes, ſeems not well founded.

But, it appears clear, that life exiſts in motion, and that, if after the motion has extended to many nerves, it altogether ſubſides, life never returns again ; and that, when from faintneſs, or other ſimilar cauſes, the body appears to be dead, yet, there remains a degree of vibration in ſome of the nerves ; this is confirmed, by obſerving a bullock, when dreſſing by the butcher, many minutes after the animal is ſaid to be dead, vibratory motion, which are evidently innate, in ſome parts of the fleſh, are conſpicuous. Hence, it appears plain, that life exiſts in innate motion ; the entire ceſſation of which, is DEATH!!!

WAKING AND SLEEPING.

Life and death, are oppoſite ſtates; so alſo in ſome meaſure are waking and ſleeping; so much so, that ſleep, by a celebrated ancient poet, has been denominated, death's half brother.

Vigilance or waking, conſiſts in ſuch preſent ſuſceptibility, and readineſs, of the nervous ſyſtem for action, that, whatever ſtimulating powers are brought to act on the external organs, or the emotions of the ſenſorium within, may inſtantly excite vibrations, and ſenſibility therein. And notwithſtanding the degree of ſoundneſs of ſleep, differs in different perſons, and in the ſame perſon at different times; yet, it is in degree only; for the nervous ſyſtem, or animal ſoul, can no more bear unremitting exertion, than the muſcular ſyſtem; and when exerciſe has been long continued, reſt or inaction, will be proportionably more permanent; and ſo unavoidable is reſt for the nervous ſyſtem, that no exertions of body or mind, nor the fear of death, can poſſibly eventually reſiſt it. The ſentinel, although he knows it muſt be certain death for him, and that his ſleeping on his poſt, endangers the lives of thouſands, yet, he unavoidably ſinks down to ſleep.

All which proves, it is a ſtate of reſt, not from muſcular exerciſe only, but of the animal ſoul alſo; and that ſleep is a partial ſuſpenſion of the ſuſceptibility of the nervous ſyſtem; by which, notwithſtanding ſome light may in ſome inſtances be admitted to the eyes; the common undulations of the air to the ear, and the uſual ſtimulants, to any of the organs of feeling, yet the nerves are not thereby moved to vibration, but continue to reſt, that they may be recruited, and their loſt tone reſtored; for, without ſome degree of tone, they can vibrate no more than an unſtrung cord. And at the ſame time the vibrations, with the attendant excited ſenſibility in the ſenſorium, are moſtly ſuſpended, or in other words, memory is deferred; but not wholly, for it is preſumed, that in the deepeſt ſleep, there is ſome weak vibrations of the nerves; i. e. ſome faint remembrance, in which ſtate. there is a variety of degrees of activity, until it becomes nearly that of a waking ſtate; for dreams are ſome times nearly as regular, rational and perfect in memory, as reflections, when watching. And notwithſtanding, diſputes have been heretofore entertained, whether it is the body or ſoul, which ſleeps, it now appears evident, that ſleep is a partial ceſſation of the operations of the animal ſoul, together with a ceſſation of the actions, of

the voluntary mufcles, which are dependant thereon for motion; while the vital, and other involuntary motions are continued by the power of habit, aided by that ftimulating, uneafy fenfation which always attends a beginning ceffation of the vital motions: by which life is continued, while the animal foul and body are recruited by reft; and that it is neither alone, nor perfectly, but both the animal foul and body, that partially fleep.

PLEASURE AND PAIN.

The nerves, by whofe motion the law of fenfibility to them annexed, is put in operation, are excited to action by innumerable ftimulants from without, as well, as by a vaft variety of reflections within; all which are either agreeable, or difagreeable, and pleafing or difpleafing, i. e. productive of happinefs or mifery.

For, there is no fenfation, that is totally indifferent to pleafure or pain.

And, as all fenfible irritation produces either pleafure or pain; fo all pleafure or pain is the effect of ftimulants or irritation.

Reflections in the mind prove ſtimulants to the muſcles; i. e. the operation of particular kinds of ſenſibility in the ſenſorium moves to action certain nerves, which are ſpread upon the fibres of particular muſcles, by which the muſcles are excited to action; and the ſenſibility, as well as the conſequent motion, will be agreeable, or diſagreeable, according to the ſource which originally produced the reflection.

But, irritations from without, produce, generally pleaſure, or pain, according to the degree of irritation, i. e. the feeling of light on the eye; of the undulations of air on the ear; of ſubſtances applied to the tongue; of effluvia to the membrane which lines the noſtrils; and of whatever come in contact with, or touches any part of the external ſurface of the body, ſo as to be perceived, are in almoſt all caſes within a certain degree of operation, pleaſing; but when the power of operation is increaſed, becomes unpleaſant; and when greatly increaſed, becomes highly painful, and when ſtill more augmented, inſupportable.

All which is within the obſervation of every one; for there is no perſon, who does not generally continue the eyes in a ſituation to receive a gentle ſhower of the rays of light, when in his power; nor is

the ear ſatisfied with hearing; and who is not pleaſed with agreeable taſtes in the mouth; or with an agreeable ſtimulus, on the olfactory nerve, ſpread upon the membrane of the noſtrils; and with gentle titilation on the external ſkin; all which, produce excrutiating pain, by being increaſed; even light, in ſufficient quantity, becomes inſupportable to the eye; and notwithſtanding the agreeableneſs of a gentle warmth from fire; yet when increaſed to a powerful degree, the tortures it produces is beyond the power of expreſſion to deſcribe.

There ſeems to be three ſtates of pleaſure and pain, viz. ſimple, compound, and a third, exceeding in degree, and more directly mechanical, than the two former.

In the firſt ſtate, the pleaſure or pain ſeems to ariſe from operations on more or leſs of the external organs of ſenſation at the ſame time: in this ſtate, the pleaſure or pain is uſually in a moderate degree.

In the ſecond, from irritations on more or leſs of the external organs of ſenſation; and at the ſame time, reflections within; hence compound vibrations in the ſenſori-

um, or aſſociated ideas, which greatly augment the pleaſure or pain.

There are innumerable ways, in which this aſſociation of ideas, or compound operations, in the ſenſorium, are conſpicuous to every attentive obſerver.

Inſtance the prattling of a favourite child, which, if it had come from a Puppy, would hardly have excited any reflections; yet from this ſource, it not only excites ſtrong vibrations, through the medium of the ear; but the vibrations, which had been heretofore excited, through the medium of the eyes, are alſo renewed; i. e. brought to remembrance; as well as a great variety of pleaſing actions, which, until thus revived, had been forgotten. And alſo, upon turning the eyes, a ſhower of rays of light, from the agreeable object, renews every vibration to full vigour; preſenting the moſt agreeable picture of innocence and ſweetneſs; and from theſe compound operations, or aſſociation of ideas, the moſt agreeable pleaſure is experienced.

The reverſe of which is experienced, when, inſtead of the agreeable prattle, dying groans from the dear object pierce the heart, and denote the excrutiating torture

the little innocent endures; which, associated with the pleasing train before experienced, produce the most poignant distress, and torture, which may be increased by a further association of the ideas, that some unpardonable neglect, or inattention had been the cause of the afflicting scene.

In the above case, the pleasure or pain, is greatly increased by the associated operations in the sensorium; which are produced by the direct stimulus of the rays of light, or undulations of air, or any other present operations of external objects, on any of the organs of sensation, as well as by the renewal of operations, which had been heretofore produced, and are now again excited in connection with the last mentioned direct ones, i. e. from compounding the ideas from direct operations on the sensorium, with those from recollection or memory,

The 3d state of pleasure or pain, seems to be more directly the production of mechanical operations; and are also more acute than either of the former, yet they are also the effects of stimulants; of which class distention and compression are, without doubt, as powerful as any whatever. For the greatest pleasure experienced by animals, is evidently the effect of distend-

ing the veſſels and muſcular fibres of ſome parts of the body; as the ſtomach when empty and its coats colapſed ſuffers great uneaſineſs; but when ſupplyed with food, and its coats diſtended, the animal experiences great pleaſure therefrom; ſo alſo, the diſtenſion and concuſſion of a great number of muſcles by ſneezing gives no ſmall pleaſure, ſo diſtending the emunctories, or outlets of ſome gland or receptacles, whoſe fibres are but ſeldom ſtirred, cauſes the moſt exquiſite pleaſure.

But in all caſes, an exceſſive extenſion produces the moſt excruciating pain; the diſtortion of the joints on the rack, can be exceeded by nothing but fire.

And it appears, that a very fine twig of a nerve, when ſtimulated by fire, diſtenſion or compreſſion is capable of communicating to the ſenſorium the moſt diſguſting ſenſation of pain: as is often experienced by the ſmall twig of a nerve, that enters the cavity of a tooth, being compreſſed by the ſwelling of the marrow, from inflammation produced by whatever cauſe.

It is unneceſſary to enumerate the kinds of pain, but to refer each one to their own experience. But it may not be amiſs to obſerve, there is not too great a ſenſibility

to pain in the animal body; if it was lefs, animals would be too indolent, and inattentive to fhun danger.

There is not perhaps, any kind of irritation that produces pain, but what, in a fufficiently mild degree, gives pleafure; nor any which is pleafing, but may be increafed to pain.

POISON'S, &c.

By the foregoing theory only, can we explain the operation of fome medicines and poifons, which produce general affections, while they remain entirely confined in local fituations; fuch as the poifon of a viper, and other deleterious matters, introduced through the external fkin, by the tooth of the ferpent, or any fmall inftrument; fome of which, produce general convulfions, or other diftreffing fymptoms over the whole animal frame, which foon terminates in death; and that, (if accounts may be relied on) before the poifon could poffibly have been in any meafure, diffufed through the circulating fluids, or when received into the ftomach, produce effects fimilar to the above, before any part of the poifon could have been tranfmitted from

it. All which, operate locally like common irritating powers; but with this difference, the poison introduced as above, whether into the stomach or flesh, remains a perpetual irritating power; not operating transiently, like the rays of light on the eye; which, however, when the ideas of the object are associated with the ideas of danger, there is a transient, universal, in voluntary contraction, or convulsion of all the voluntary muscles in the body; but, the associated ideas of danger being removed, or the eyes turned from the object, all is again quiet. But, there are undoubtedly some persons, who have such delicate and irritable nerves, and who have so strong an aversion to some particular object, whether a snake, or some other thing, that if confined in a situation uninterruptedly, to receive the irritation of light to their eyes, from the detested object, that symptoms no less violent, would be experienced; and, if the poison could be as entirely removed, and excluded as the light, from the hated object, it would prove no more destructive.

Hence, it is evident, that notwithstanding the effect is general, the operation is local; and also, that danger is in proportion to the degree of irritation, as well from the poison as the light. For the most

ſalutary medicine becomes a deadly poiſon, when the irritation is increaſed by augmenting the doſe; and its ſalutary effect is as much produced by a local operation, as its deadly,* which muſt all be conſidered as evidence of the propriety of the foregoing theory; for it appears not eſſential, whether the irritating power operates on the finger, the ſtomach, or the eye, to produce an effect generally through the body either ſalutary or deadly. The exact mode of its operation, to produce either of the laſt mentioned effects, has been deſcribed, when treating of muſcular motion, &c.

Nervous diſeaſes, if enumerated by the variety of appearances which they exhibit,

* I have seen a child two years old, who had languished in pain and distress, during forty eight hours, unable to be on its feet; so much relieved by taking two drops of liquid Laudanum, and two of essence of Peppermint, that in less than fifteen minutes, it was on its legs at play. And other causes in which similar operations of opiates, have been experienced; in which no part of the medicine could have passed the stomach. And when a large quantity of opium has been taken, with a design to destroy life, upon dissection, it has been found, remaining solid in the stomach. Although opium relieves pain, and gives such great pleasure, yet, the convulsions produced by it, are as painful, as those from any other cause.

would be almoſt innumerable; but, excepting thoſe which are ſymtomatical, or the neceſſary conſequence of that debility which is inſeparable from them, in connection with the reſt of the body, when reduced low by violent, or long continued ſickneſs, they may be reduced to a few ſpecies, viz.

1. Apoplexy, comprehending palſy, carus, coma, and lethargy.

2. Epilepſy, comprehending hyſterical, or hypochondriacal affections and hyſteric, or hypochondriac fits.

3. Tetanus, comprehending triſmus, or locked jaw, opiſthotonos, and emproſthotonos.

4. Spaſmi, comprehending convulſions, convulſion fits, and catalepſy.

5. Chorca, or St. Vituſ's dance.

6. Mania, or madneſs, comprehending diſtraction, incoherency of ideas, and unſound memory.

7. Hydrophobia, or dread of water, canine or dog madneſs.

8. Debility, or laxity of tone.

A few brief remarks on each of the foregoing, is as much as the ſtudied brevity of this work can admit of.

It ought to be mentioned, that it is not conſidered certain, that the foregoing unſtudied and hurried ſpecification, is altogether correct, but that ſome addition, or reduction, would be not only convenient, but uſeful. It was not intended to attend any more to theſe ſubjects, than their connection with the foregoing theory ſeemed to demand, or than would prove eluſtrative thereof.

It is conſidered, that apoplexy, carus, coma, and lethargy, differ only in degree; that they are produced by the ſame cauſes, and require ſimilar treatment. The cauſe may be extravaſated blood, or other fluids, or any other ſubſtance, compreſſing that part of the brain, where the nerves are concentrated; i. e. the ſenſorium, whereby the nerves there, are confined from motion, and ſenſibility cannot be excited; or from any other power, operating on the nerves, in any other part, by which mobility is prevented, and ſenſibility loſt; or a defect in the nerves themſelves, whereby

they have become insusceptible of irritation, or have lost the power of motion.

When the disorder is general, in symptoms and appearances, it resembles a deep sleep; and seems, not in much else, to differ from it, but only in this, that the nerves distributed to the voluntary muscles, cannot be roused to action; and the law of sensibility thereby excited; or in other words, the person cannot be awakened from the disorder.

The best method of treatment, seems to be, to endeavour to remove the compressing cause, whatever it may be, from the sensorium; or to restore the nerves, in all parts to their pristine state of activity.*

EPILEPSY, &c.

Notwithstanding epilepsy, hysteria, and hypochondriasis, have been joined in the foregoing arrangement; yet, it seems

* It is thought warrantable to reccommend a free use of stimulants externally, applied as well to the head, as to other parts, and a free use of the sharpest sternutatories; for, if a free discharge from the nose, together with frequent sneezing, could be excited, it is believed nothing would warrant greater hopes of success.

doubtful, whether hyſterical and hypochondrical affections ſhould not have been placed by themſelves. For they appear more particularly, to be produced by errors, in the firſt paſſages; ſuch as debility of, or acrid humours in the ſtomach and inteſtines; or eating indigeſtable aliment, which irritates by its hardneſs, or its roughneſs, their nervous coats; or diſtends them with wind, by fermentation,* or

* The greater part of the chronic disorders of children are of the above kind; owing principally, to the laxity of the fibres of their first passages, and the disposition of the milk, by which they are supported, to become sour; which, when it has arrived to a high degree of acidity, turns of a green hue; and when much higher to that of black; when it becomes almost as corosive as oil of vitriol, by which, not only the internal coats of the stomach and intestines are corroded and lacerated; but by its application, the external skin, in some instances is eroded and destroyed.

This source of inexpressible misery and torture to those tender sufferers, who lack the power to describe their unhappy situation; which, however, is not lessened by their feebleness, progresses from a degree of acrimony, productive of a distressing uneasiness, to a state of sharpness, productive of such misery, that, had the subjects the power of expression, language would fail to communicate what they endure: until the nerves can bear the irritation no longer; when irregular, violent and involuntary excitement of the law of contraction in the muscles takes place, and convulsions, with remissions, and recursions, after some hours, or days put a period to life.

The inability of the infant to describe; and, too often the inattention of the physician, and the total ig-

from debility, or irritation of ſome other of the abdominal vicera, on all of which, nerves are numerouſly ſpread; so much so, that ſome of the ancients, fancied the

norance of all others concerning it, prevents all knowledge, (as well in the early stages, as in the progress of the disorder,) of the seat, cause and necessity of the application of proper remedies; by reason of which calamities, great numbers of the tender subjects fall victims to the disease.

If, before the disorder is too far advanced, it is understood, and proper measures pursued, the greater part may be saved; and much pain and distress prevented, in those who seem not in danger, and who eventually recover.

The direct cause, in almost every instance, is acidity or sourness, which is caused by debility or bad aliment; debility is either in the natural make, or constitution of the body; or is the effect of bad air; the want of exercise; the want of sufficient cloathing; the want of cleanliness; the effect of some other disease, or poisonous matter, or the want of nourishment.

The effects of the first, are to be guarded against, with the greatest caution; the latter, if possible, to be shunned.

To guard against effects of natural debility, the above mentioned causes of debility, must be scrupulously avoided, that the natural debility may not be by them increased.

But when, from whatever cause debility has taken place; and acidity is accumulated in the first passages; it is but seldom useful to attempt to purge it off; nay more, but, except in quite the first stage, or costiveness demands it, purging is generally injurious: nor is it of any advantage, for the acid matter, will be quickly again accumulated, and its cause, debility, will be thereby increased.

ſtomach to be the ſeat of the ſoul. By the diſturbance of ſuch a multitude of which, it would be ſtrange, if diſorder ſhould not be produced.

It must be carefully kept in mind, that the disorder, of which we are now speaking, is a chronical effection, and of the asthenick kind.

There is another disease, not uncommon to children; which is, in its nature and cause, almost diametrically opposite to this just now spoken of. It is an accute fever, and more or less of the sthenic kind. Our limits will not admit a description of the two diseases; but a few observations may not be amiss to those, not versed in the knowledge and symptoms of disorders.

The last mentioned attacks more or less violently, and is attended with the symptoms, common to fever, in children; which, from the difference of constitution, deviates a little in appearance, from those in adults. It is sometimes called worm fever, sometimes bilious fever, at others, inflamation in the bowels, and sometimes, a stoppage in the bowels, &c.

In this fever, although the tender frames of infants cannot bear to be greatly reduced; yet, that viscid matter tinged with bile or atra billis, which in some instances, so lines the internal surface of the stomach and intestines, that the sharpest physick, can hardly be made to effect them, must be purged off, without any regard to the strength of the patient. Calomel, from half a grain to two or more; (and it has been given in a dose, of more than twenty, with success, but it seems better to repeat smaller ones,) once in, from two, to twelve hours, and at the same time, to give senna, steeped in a solution of alkaline salts, or, in an infusion of common ashes, settled and poured off clear, (the strength of which must be carefully adapted to the tender state of the mouth and throat of the patient,) almost constantly, and jalap in pow-

Theſe complaints in many inſtances, (although tedious to the patient,) are for conſiderable time, comparatively mild, and confined to the parts laſt mentioned: yet,

der or infusion, without fear; and to use glisters, made strong of the same; all of which, with many others, are to be used as the case may require; but with boldness, for the life of the patient in stubborn cases, depends upon evacuating the above viscid atrabillis, and when the passage is so lined with viscid matter that physick cannot but with the greatest difficulty be made to operate thereon, very little caution is necessary, in regard to the quantity or strength of the same. To patients under two years old, I have seen jalap in powder and infusion, and senna almost constantly administered; and calomel freely, for many days successively: by which viscid matter resembling the meconium or tar, was by assistance of injections, but slowly evacuated; and the practice was eventually successful. But such cases are not common, and are usually fatal to the patient.

But in the first mentioned chronical disease, when the acrid matter, generated within the body, is operating as poison in the bowels, they will illy bear the addition of the poison of physick to augment the malady. Yet, when there is real costiveness, gentle, emolient, and mild purgatives, must not be omitted; but on account of which, the following remedies, must not be in the least put by: but such quantities of emolient, mucilaginous and soft solutions, or broths, or the like in any other form, as the stomach can bear; must, at the same time be administered.—Anodynes, in any form; but elixer, paragoric, or liquid Laudanum, seem most convenient, to administer to children. It is most prudent to begin with small doses; but which, must be increased, and oftener administered, until they cause ease; even if large quantities should be required to produce the effect; for,

ſometimes ſuddenly, but oftener progreſſing gradually, they become general; and eventually exhibit, nearly, if not exactly, the ſame ſymptoms, that mark epilepſy, by

there remains but small hopes of a cure, in stubborn cases, when anodyne admini tered in proper quantities do not give relief.

Alkaline salts, such as sal. Tartar, Pearlash, or the salts from common ashes, procured by putting hot ashes into water, which, after settling, must be poured clean from the sediment: all of which, must be carefully accommodated in strength, to the tender and sensible state of the childs mouth, &c. and so often repeated as to overcome, and neutralize all acidity in the first passage. The foregoing, with many others, if properly used, willbut seldom fail of giving relief.

The important effects of one of the causes of debility, will appologize for a few observations concerning it.

The excessive heat of summer and autumn, not only directly debilitates, the tender habits of infants, but also greatly increases the badness of the air, in populous towns, which is also another great source of debility, and appears to be the cause in those seasons, of the great prevalence and fatal effects of this disease in such towns; sometimes proving so destructive, that it has been considered a different disease, and has been denominated, cholera infantum, &c. proving so exceeding obstinate, that the best remedies, in some instances, have produced but little sensible mitigation of its violence.

But, why should it be considered, another, or different distemper, when the cause of its stubbornness is thus conspicuous; for those stubborn cases, are but rarely to be met with, in the open country, where the air is pure! they are therefore, evidently one, and the same disorder; the severity of which, is increased by the badness of the air, in more populous towns; where it appears, in its greatest malignity.

which, violent paroxifm, the patient is relieved, from that almoft infupportable diftrefs, faintnefs, trembling, &c. at the ftomach and bowels, for a longer or fhorter time; or, in many inftances, until fome error is committed, by eating, drinking, overlifting, or fatigueing exercife; or perplexity, or irritation of the mind; all which are extremely hurtful, to thofe who are

The effects of bad air, on the tender constitutions of children, prevents that firmness of body, necessary to enable them to avoid the attack, or withstand the dangerous effects of the disease; and is probably the cause of the disappointment that has so often been experienced by those, who have removed their children from populous towns, into the country, for safety upon the attack.

Wherefore, they ought to remove them, before the attack. And those, whose children have been peculiarly subject to the same, and who have great anxiety for their safety, ought to remove them into a pure air, before the hot season begins, that they may not be debilitated thereby; by which precaution, they would be nearly as safe, as those bred in the country; for, if they should be attacked there, the danger would be comparatively small, to what it would be in a populous town.

Concerning the use of medicines, it may be observed, that much of the benefit, that might otherwise be derived from the best practice, is lost by the conceitedness, obstinacy, or ignorance of nurses. And there can be no fear of censure from the faculty, for saying, it is sometimes the case, (and it might be said, too often,) that the nurses judgment is best; for the most ignorant, being the most conceited, will not take it to themselves; and those of real learning, will coincide in the opinion.

ſubject to the foregoing complaints. Notwithſtanding which, as free a uſe of ſuch nouriſhing diet, as will prove perfectly eaſy in the ſtomach, ſupporting cordials, in proper quantities, exerciſe on horſeback, or in a carriage, or of any other kind which is not fatiguing, and above all other things, cheerfulneſs of mind; which ought to be carefully promoted, are the beſt, and almoſt the only remedies; and are by much the ſafeſt, pleaſanteſt, and cheapeſt. It is not intended, that medicines, in ſome caſes, may not be abſolutely neceſſary.

Hyſteric and hypochondriac affections, ſeem to originate in the ſtomach, and bowels; but the univerſal diſturbance that inſtantly takes place upon the attack of epilepſy, ſeems to denote its cauſe, to be in, or near the ſenſorium; which appears to favour the idea, that they are produced by different cauſes. Yet, it is altogether uncertain; for, an orgaſm produced in any part, may be ſuddenly communicated to the ſenſorium; from which, the nerves in any, or all parts of the body, may be excited to vibration, and involuntary muſcular contraction, or convulſions thereby produced.

There are evidently, a great variety of operations, on different parts within, that

produce either of them. So alſo, there is from without, the irritation of rays of light on the eye, may produce them; it is not uncommon when ſeveral perſons are together, who are ſubject to hyſteric fits: that one being thrown into a paroxyſm, the others, by ſeeing her convulſive ſtruggles, will alſo fall into the ſame convulſive ſtate.

And an epileptic patient, being brought into a hoſpital for children, the other patients by beholding his frightful ſymptoms, were one after another, all ſeized with the ſame fits; which recured from habit, without the firſt exciting cauſe; and when one was ſeized it would affect all. These were cured by the operation of light on the eyes; effected by the following ſtratagem. After removing the epileptic patient, they were cauſed to behold a great number of holes, burned with a red hot iron, in the ceiling of the room, in which they reſided; and were ſternly told, that the firſt who ſhould be ſeized with a fit, ſhould have his tongue burned through in the ſame manner. The holes burned in the ceiling, continuing in view; the preſent impreſſion of fear, overpowered the impreſſions on the mind, of thoſe ſtruggles they had before beheld, and thereby prevented any return of fits among them.

From the foregoing, and many other phænomena, in the procefs of epilepfy, &c. it is plain, that in all thefe diforders, there may be a great variety of caufes, both external, and internal, which may operate upon various external parts, and almoft all within; and that it is ftill doubtful, whether they ought to be confidered, as of different characters, or one difeafe; differing only in degree, being in fome inftances local; in others, more extended; and fometimes general; depending much on the habit of body, being more or lefs favourable, for extending local affections of this kind.

We have before feen, that the operation of light, on the eyes of thofe whofe nerves are peculiarly irritable, reflected by certain extraordinarily difguftful objects, and uninterruptedly continued; may caufe as violent convulfions, and diftreffing oppreffion of the vital organs, and prove eventually as fatal, as any poifon whatever; whether they are received into the ftomach, and continue to irritate the nerves thereof; or, being introduced to the nerves in the flefh, do there continue to irritate the fame; i. e. all poifons deftroy life by irritation; but the irritation of light may prove as fatal, as that of arfnic, in the ftomach, or the poifon of a viper in the flefh.

Or in other words, the rays of light, under certain circumſtances, are as fatal a poiſon, as any other poiſon whatever.

And in the caſes above mentioned, we have inſtances in which, irritation of light, on the nerves of the eyes, has cauſed tedious, and even dangerous, general nervous diſorders, or hyſteric and epileptic fits; and we have alſo, an inſtance of the irritation of light on the eye, and the vibrations it produced in the ſenſorium, when aſſociated with others, produced by the irritation of undulations of air, on the nerves of the ear, proving a moſt ſalutary remedy for epilepſy; and perhaps the only remedy, that could have been invented, for the diſorder ſo produced.

All which, it is believed, no one will refuſe to admit, as evidence of the truth and propriety of the doctrine, that irritation and ſenſibility, are governing principles, in the animal kingdom.

Tetanus, Trismus or Locked Jaw, Opithotonos and Emprosthotonos, may either of them be produced, by a variety of cauſes; each, of which cauſes, may produce either of them, alone, or the whole con-

jointly. And the method of cure, need not be much varied, on account of the appearance of the ſymptoms; but, in ſome inſtances, conſiderably on account of the cauſe.*

* There are doubtless, causes yet unknown, which produce tetanus; but, lacerations of nerves, interwoven with the fibres, or spread upon the surfaces of tendons, ligaments, membranes, &c. whether in gunshot, or other wounds, are evidently, the most common causes.

Another cause, is long continued exposure, to extraordinary cold and wet; such as wading in swamps, and sleeping on the ground, exposed to storms, &c. There is sometimes considerable difference in the appearance of the symptoms, when the disorder is produced by the foregoing different causes. And it requires a still more different method of cure.

When it is the effect of the first mentioned causes; mercury, internally and externally applied, can hardly be used too freely; with opium in great plenty, and other remedies as the case may require. But, the application of heat around the body, by boiled blocks of wood, or bottles filled with hot water, &c. are injurious.

Yet, when it is the effect of the last mentioned, i. e. cold, &c. heat so applied, to a degree, that is not tedious to the patient, and continued with little, or no remission, for a long time; has, without the aid of other remedies, effected a cure.

But, from ignorance of the difference of treatment rendered necessary, by the difference of cause producing the disease; the injudicious application of heat as above, and neglecting other necessary remedies, has cost the patient his life.

Wherefore, it is confidered, they are one, and the fame difeafe; differing only in degree, and the different part it may chance to operate upon.

SPASMI, comprehending CONVULSIONS, CONVULSION FITS, and CATALEPSY.

When a fingle mufcle is involuntarily, and violently contracted, it is vulgarly denominated cramp; when the contraction has extended to many mufcles, convulfions; and when general, convulfion fits,* in that ftate, denominated catalepfy; the flexor, and extenfor mufcles, or, thofe

* There appears to be one cause, different from those, by which, convulsions are usually produced; i. e. plethora, by which the blood vessels seem to be so distended, as to compress the nerves, at the sensorium, to a degree, that prevents a regular operation thereof. For the first symptoms, are spasmodic pain, or twinging in the head and eyes, with aguish rigours, extending over the body; and if not prevented, excruciating convulsions ensue, which may terminate in apoplexy..

The patient is speedily relieved, by bleeding a sufficient quantity. It may not be amiss to add, that the last mentioned, is sometimes a distressing symptom before, or at the eruption of the meazles, &c. and is relieved in the same manner. But convulsive disorders, when the effect of debility, by no means, admit of bleeding.

which bend, and thoſe that extend the limbs, are contracted with exactly equal power; by which means, the body, whether lying, ſitting, or ſtanding, if equally ballanced, will remain in the ſituation it was in, when attacked. Theſe paroxiſms, recur at different periods from ſome hours, to ſeveral days diſtance; and continue from ſeveral minutes, to hours. (A ſimilar ſtate ſometimes appears in tetanus, but which, in ſome caſes, varies a little in its appearance, and continues weeks; and ſeems in no other reſpects, to differ from the above, only, in the ſtubbornneſs of its cauſe.) They all ſeem to be one diſeaſe, differing only in degree.

Chorea, vulgarly called St. Vitus's Dance, does not affect the ſenſorium, in any degree. Nor are the ſpaſms, of but ſhort continuance; if in reality, there are any ſpaſms in the caſe; for, the voluntary contractions are by no means violent; but the muſcles ſeem not to be ſuſceptible of the exciting power, moved by the ſenſorium, to produce muſcular motion, but appears to act independent thereof, at times. Hence, the voluntary motions, are in ſome inſtances ſuſpended, and thoſe that are involuntary take place.

Or the ſenſorium may be defective, and err by exciting motion in other muſcles, than thoſe intended; for, when it would be more convenient, for the flexors to contract, it proves to be the extenſors that do contract; and the veſſel of drink, that is intended to be brought to the mouth, and to which, it has nearly arrived, is forcibly carried from it by the patients own hand, to his no ſmall mortification; but when he has the good luck to bring it to his mouth, he pours it down with violence, which ſhews that the muſcles in performing that operation, obey the will; and there being no derangement of ideas, ſeems a ſtrong argument that the ſenſorium is in no meaſure diſordered; and from obſerving the motions of the patient, it appears moſt probable, the defect is in the nerves, ſpread upon the muſcular fibres. Peruvian bark having been found the moſt efficacious remedy for chorea; and it being the greateſt tonic, or bracer; is considered an argument in favour of the idea, that the diſorder is the effect of debility in the nerves generally, and not of the ſenſorium particularly.*

* To prevent repetition, already too often admitted, for the purpose of perspicuity; the explanation of the mode of operation in the process of spasms, or convulsions, in epilepsy, tetanus, spasmi, and chorea, and the disorders conjoined with each of them, has

MANIA OR MADNESS. The ſimilarity there is in this diſorder, to that ſtate of the ſenſorium, cauſed by provocation, when in health; renders ſome brief reflections on

been omitted: it will here be attempted in as concise a manner as possible.

An attempt has already been made, to explain the modus opperandi, in the process of voluntary muscular motion. The operations of which, we are now speaking, are also, muscular motions; but are involuntary, and it matters not, whether the involuntary contractions are gentle, as in chorea, or violent, as in tetanus; for the cause is the same, notwithstanding the difference of degree.

It is evident, that any kind of irritation, whether external or internal, may be the cause of muscular motion. So also it appears, that almost any kind, if sufficiently violent, or long continued, may produce involuntary contractions; such as the operations of light on the eye, of poisons in the flesh, or stomach, &c. as has been before explained. So also, may many other matters or things, in any part of the body; whose particular seat in many instances, is not in the least made manifest; nor can, by any art be discovered; but which does, like poison in the flesh or stomach, cause ungovernable excitement in the sensorium; by which, without design or choice, the muscles are contracted:—Instance, a puncture by a needle or thorn, in a finger or toe, which can be known to be the seat of the cause of tetanus; only from the knowledge or remembrance, that the puncture had been previously made in the particular part; for, if the wound inflames, and becomes painful, it never produces tetanus; and there may be some doubt, whether a cure can be performed, without amputation, or producing scarification, and inflamation in the injured part, by stimulants.

the latter, neceſſary. That greater conſtitutional excitability of the nerves of which the ſenſorium is compoſed, in ſome perſons, than in others, cauſes them to be more

It appears not a little astonishing, that, from a wounded nerve or nerves, in which, no uneasiness or pain is known to the patient; there should be communicated to the sensorium, such an ungovernable excitement, as to produce those violent contractions of the muscles, that appear in tetanus; by which, the jaw is so strongly locked, that it is reported to have been broken, before the muscles would give way, in attempting by prying, to force the mouth open.

From this, and other phænomena, it appears evident, that the involuntary contractions, in the foregoing disorders, often originate from causes, in various parts of the body, altogether beyond the power of human discovery; and that the different appearances which they exhibit, are caused by the different part that is affected, and the different power by which produced.

Or, they may sometimes be the effect of a peculiar kind of debility; or a kind of inactivity; by which, there is a suspension of motion, in some of the nerves at times; and the energy of the sensorium, becomes accumulated, by not being exhausted on those inactive nerves; whereby others must receive too great a share thereof; and the most effectual method of cure, seems to favour the last idea; for the peruvian bark, is found to exceed any other remedy for the cure of chorea.

And tonics, such as tincture of gentian, orange peel, &c. has sometimes quickly relieved hysterical complaints, when the class of anti hysterics gave no relief; and in general, the best nervines, are such medicines as have a strong smell; which shews their componant parts are extremely divisible, to a degree, that they may pervade the finest pores; and they are

prone to anger. Or it may be caused by over fatiguing; which, by too much wear, has increased the excitability; or it may be the effect of disease; or of the stimulous

also generally stimulating by their pungency; and by those qualities, give tone and activity to the nerves; and by their giving additional strength, and power to the nerves, although they are not in fault, may enable them to withstand the unnatural operations, to which the latent case is drawing them.

Although there still remains no small obscurity concerning nervous disorders; yet it is confidently hoped, we have, by aid of the newly proposed doctrine, gone much beyond what has been before proposed.

It would be pleasing indeed, if, by further advances in knowledge, the hidden seats of the cause of so much human misery, might come to view. But there are but few diseases which terminate fatally, that are not sooner or later, evidently attended with some or other of the symptoms of those original diseases, which, with the present appearance of things, seem rather to indicate they must remain monuments of human imperfection; possibly to counter balance happiness derived from other sources; that the perfect equilibrium of happiness and misery, ordained by the creator, may be supported.

Nervous diseases, have at all times been considered dark and mysterious; so much so, that in all ancient nations, they have been in all their various forms, considered supernatural productions, and ascribed to the wrath of the gods, the possession of devils, or witchcraft. The description of those possessed by devils, answers exactly to the symptoms of fits in modern times. It was said of Saul, that an evil spirit from the Lord was upon him; it was truly an evil disease; the like of which, had time immemorial been consid-

of intoxicating ſpirits, on the nerves. But, from whatever cauſe the operation appears to be, an over ſtrong vibration of ſome of the nerves of the ſenſorium, by which the

ered by people of all ranks, to have been the operation of evil spirits, and it was totally immaterial to the people, what caused his distress; but, it now appears most probable, from the history of the case, that a long continued series of misfortunes, disappointments, and over exertions, had relaxed the tone of his nerves, and produced that melancholy state, described under the last head of nervous diseases, viz. debility, &c. at the last part of this appendix. And it had been discovered, in those early times, that m usick relieved such complaints. So also, it has in modern times; I have seen a case, where fits recured diurnally for some months; which could at all times be removed, and kept off, by lively musick, either vocal or instrumental; which was not omitted, probably a single evening for some months, when sound health was restored; but a dirge or mournful tune, would at any time cause fits; from which, by shifting the tune to a lively air, she would be again relieved. It is also well known, that diverting and cheering the mind, is the best remedy for melancholy.

By the light of reason and philosophy, it is now known, that nervous diseases, are not of supernatural production; but like all other operations, are the effect of natural causes; and happy indeed, it is, for the sick, that the discovery has been made; for, they are not now banished, as unfit for human society, on account of being under the operation of divine punishment; or, on account of being the associates of devils; or being under the controul of witches.

Nor are mankind in but a small degree, sensible of the benefits they enjoy, from the discoveries of truth, and expansion of reason, by the light reflected by phi-

law of ſenſibility is highly excited, producing an irkſome, painful ſenſation, more acute or mild, according to circumſtances. All which is evident, from the rigid,

losophy. For, in the dark ages, when it was the general opinion, that all were destined for eternal damnation; excepting only those, whose sins were pardoned by the pope, or his deputies. And when those who were accused of public crimes, were not allowed council, when on trial; nor the privilege to have witnesses examined, to prove their innocence.

It was at the same time, the opinion of the friends and attendants of the sick; that whatever was for their comfort, was injurious and dangerous, of all which, therefore, they must be denied. And so strong was the prejudice, that their best friends, if friends they could be called, in their distress, would rather treat them with roughness and moroseness, than with pity and compassion. Millions of millions of whom, have languished to death, in spite of intreaties; not only in the small pox, but in all other fevers, for want of cool air, and cold water; which alone, (might they have enjoyed those free gifts of nature,) without other remedies, would have saved them; but they must be secluded from every breath of pure vital air; and breathe over and over, the air contaminated with the poisonous effluvia of their own half putrid bodies; (quite too much of which practice, prevails at the present day,) and if they were allowed to wet their parched mouths, instead of the pure liquor of life; which, not only their own feelings, but that of the whole animal creation, dictates to be pure cold water; some warm slop, rendered hateful by the infusion of some nautious herb or root, was the most they were allowed—thus, an irresistible prejudice, in favour of some indigenous herb or root, which is usually without efficacy; but which, if it possess in any degree, it is generally stimulant; which, in the first stage of fever,

hurried, and ungovernable ſtate of the muſcles of the body in general, both voluntary and involuntary; and is of longer, or ſhorter continuance, according to the more or

can never be used without danger. But from the use of which, no reasoning can dissuade; although it is in no respect preferable to weak bohea, or other teas, made pallatable with sugar. Or, if warm drink is thought necessary to promote sweating; hot water sweetened with molasses, or some other simple and agreeable diluent, is much the safest.

But, if the patient eagerly craves cold water, it ought in all cases, to be tried, notwithstanding there are cases, in which it may disagree; but that may soon be discovered by trial; and if it evidently causes sickness, or pain at the stomach, feebleness of the pulse, or general weakness or faintness, it must be discontinued; and warm wine or spirits, and water warm, or not too cold, given without any reserve, until the pulse is raised, and the strength increased.

More has been said concerning the above erroneous conduct; as some of the last, too much prevails at present.

It is pleasing to reflect, that reason dictates the exercise of humanity and benevolence, toward those distressed with sickness. And it is earnestly hoped, that the time is not far distant, when rulers, throughout the enlightened world, will, to the utmost of their power, promote the happiness of mankind; and when the people will have the good sense to be judged, by chosen, honest, and learned judges; and not by those, whatever their characters may be, who are appointed for party purposes; for, there are parties in all governments, but in those, which are absolutely tyrannical; but one party dares to speak; nor by ignorant, or knavish jurors, whose names are by chance, drawn from the box.

There is an error, prevalent at the present day, not

lefs quick natural difpofition of the nerves, to be operated upon by different matters; or, as other things may operate, which produce different vibrations.

much dissimilar to that before mentioned, which prevailed among the ancients; of ascribing nervous diseases, to supernatural causes; but which is much less pardonable, in this enligthened age; and, the evil of which, is much increased, by its being patronised by many persons of the first respectability, for natural and acquired talents; (except in the medical art;) notwithstanding, they are looked up to for examples, by the multitude. The only difference is, the ancients ascribed the diseases to supernatural causes; and the moderns the cure.

Nothing can be more surprising to those, who have correct ideas of the matter, than that the attempts of the most ignorant medicaster, should succeed to impose on mankind; in that, which is of the first temporal importance, that they should intrust their lives and health, and that of their families, to the care of those, with whom they would not intrust the care of their cattle. Yet, when one who is destitute of all knowledge, and who, if he has any kind of system, it is systematic ignorance; who, to insure success, must have natural oddities, or assume peculiar singularity; if black the better; but if a foreigner, and claims to be a German, it may do; he must have undaunted confidence, and impudence enough to lie at at all times, without change of countenance, and art sufficient to appear modest; in fine, his appearance and character must be such, as to remove all doubt, that what he does, is not performed by any natural means, and his address sufficiently bold, to cause many of those who hear him, to think, they believe true, that which, they in their consciences disbelieve.

Thus accomplished, he has only to proclaim himself, a profound physician, or a finished surgeon, and

But, that languid ſtate of the nerves, productive of that ſtate of the animal ſoul, called fear; being a ſtate directly oppoſite to that of anger, is above all others oppo-

he can impose on millions. And it is no plea in excuse, that he takes but a trifle for what he does; nor even, if he takes nothing for the time and money, spent in going to, and attending upon the business, &c. by such numbers, is of no small consequence. But, that is not all the mischief, for many of those, who are really disordered, by attending to such impostors, neglect applying to those who are capable of giving salutary advice; until it is too late to receive benefit therefrom, and their lives are lost by the imposition.

If he profess to set bones, his greatest art consists in reducing those that are not dislocated; and there can be nothing more easily done, to the satisfaction of the patient. For when by violence, a bone has been forced from its articulation, the ligaments, &c, which support the joint, by their contraction, or cramping, instantly reduce the bone again to its place; but, the ligaments, tendons, membranes, &c. around the joint, are greatly injured; by which the joint becomes useless, and extremely painful. And this is usually the state of the case, when the patient applies to have a bone set—all the famous esculapian has to do, is, to extend and twist the limb, by which, the injured joint suffers excruciating pain; until the patient is convinced he has suffered enough to have the bone reduced; which, after such torture has ceased, will feel quite agreeably; and he can have no doubt, but the bone was reduced by the operation. And in time, the joint becomes sound, which he relates to his neighbours, with great applause of the operator; who, he says, performed the business almost without pain.

But, if the head of the bone has catched over the edge of the socket; or by any other means, the bone

fed to it; and the ſtate of the ſenſorium, which produces the ſenſations, denominated pity, compaſſion, caution, prudence or conſideration, are only different modes of

has been prevented from returning spontaneously into its place; (but which is not common) it will be left unreduced, and the patient must remain a cripple, to the injury of society.

A little reflection must convince every reasoning mind, that the healing art, (which comprehends an inexhaustible field of matters to be understood, before the practitioner can be a perfect master of his business; to which, in fact no one attains,) does not come spontaneously or naturally to any one, more than other sciences. One may learn mathematics with more ease, and vastly more expeditiously, than another; and some are blest with extraordinary mental powers, to acquire the knowledge of any, and almost all things; but study and application are absolutely necessary to become a mathematician; nor can any one acquire the knowledge of physic, without study and instruction; nor the art of setting bones, without a knowledge of them and their connections, when in their regular and natural situations. And, excepting the difference of abilities to acquire knowledge, physicians and surgeons, excel others in their professions, in proportion to their attention to study, and their means of information. It is absurd then to suppose, any one is naturally a physician or surgeon. Why then, are the most unlikely of all people to have knowledge, those who, have but barely common information or learning; and without any knowledge in the rudiments of physic, extolled beyond those, who unceasingly apply themselves to study, and the acquisition of medical knowledge?

I will answer the question. Because credulity swallows time after time, and at all times, the full cargo of marvellous reports, that are transported on

fear; prudence, caution, consideration and pity, are fear of, or being on ones guard against injuring ones own character, or of suffering remorse and sorrow, for having

the wings of fame; which is quite too much to be ascribed, to that which is natural; wherefore, the wings of imagination are extended, and excited by the pleasing hope of bidding defiance to disease and death; delusion is transported to supernatural information; and it is believed, without doubt or examination, that this prodigy in nature, this fatal enemy of disease and death, is inspired from above or below; and no matter which, whether by the spirit of truth, or by the prince of darkness, if disease and death may be defied.

That people do in fact know and believe, that they ascribe the unnatural knowledge, they imagine, those ignorant pretenders possess to supernatural causes, may be doubted; but that they have sense enough, if they do but use it, to know it cannot be natural, is without a doubt; and consequently, they must, and do, in their hearts believe they are mediums, through which, inspiration, divination, or witchcraft operates. That those, whose inquiries and reflections, are not accustomed to extend beyond the common diurnal round of breakfast, dinner, supper, and lodging; should be thus erroneous, is by no means strange; but that those who possess talents and acquirements should give lead to, and patronise such hurtful and dangerous errours, is unpardonable; for, if such would withhold their encouragement, such impositions would dwindle to trifling inconveniences.

That erroneous prejudice, in favour of so many indigenous medicines, among many people of the first respectability, ought to be examined or abandoned; for, by little enquiry, all may become satisfied, that there is as little deficiency in that, as in almost any other matters whatever.

inflicted unnecessary, or unjustifiable pain, or sufferings in others. And are the essence of those noble human qualities of benevolence and charity, that were bestowed

A very worthy and learned professor, (if my memory serves me) of natural philosophy, of a University, who was also a congregational minister of the gospel; called on me, and requested I would furnish him with some book, descriptive of herbs, &c. for, said he, I am satisfied there is a great deficiency in the knowledge of remedies, our own country affords for the diseases incident to the inhabitants. And I have determined to write on the subject; I put into his hand a book, containing a disertation, by Doctor Rush, which I thought would be satisfactory. After some months he again called, and politely thanked me for having put into his hand, a book so congenial to his wishes, saying, he was fully satisfied.

The truth is, much the greater part of the herbs and roots, that the earth produces, were not designed for medicines, but for food for animals. But there are a number, some of which, are powerful in their operations, that are useful; but which are often erroneously used by the ignorant. The knowledge of which, is a part of the healing art, and will never be understood, but by those who have systematical knowledge. It is erroneous to suppose, the Aborigines of America have any better knowledge concerning them, than the good women among us; for they have no system, nor the knowledge of letters to enable them to accumulate sufficient knowledge, whereby to compose, or continue any thing of the kind. And their methods of practice are unpardonable, even among savages; to bake a sick person, in an oven made of sods, till he is near expiring; and from that, suddenly to plunge him into cold water, cannot be justified even by the power of precedent. It was notwithstanding, a shrewd observation of an Indian, when asked

on man, by a beneficient Creator; and which diſtinguiſh mankind from devils. That which is commonly called courage, and is conſidered the oppoſite of fear, ought rather to be denominated fool hardineſs. Such as voluntarily putting ones own life at ſtake, for an imaginary injury, or that, which it is believed, others may conſider an injury; and on whoſe opinion it alone depends, to become an injury or not. Or which is ſtill worſe, to become the voluntary murderer, of one who is innocent, or guilty, in but a ſmall degree, too trifling to be worth notice; only on account of fearing, others may believe one has been injured, (it was ſaid on account of fearing,) therefore, ſuch conduct originates in cowardice, and not courage.

But, true courage conſiſts in voluntaryly hazarding a leſſer injury, to prevent a greater; which, from circumſtances, appears unavoidable; or, in hazarding of

what a certain herb was good for; (meaning what disease.) he inquired if the cattle would eat it; and being answered in the affirmative, replied, "good for nothing."

There can be no doubt, but the digressions in this note, will be censured, not being connected with the theme of the work; but, they are connected with the happiness of society, and whatever proposition has tendency to promote the happiness of mankind, may be justified.

few, in a wife and prudent manner, to fave many from danger and deftruction.

But, if anger is unreftrained by fear, in any of its modes of operation, it muft be worn out by time and patience, or the irkfome, rigid, and hurried ftate of the nerves, will drive the mufcles to acts of violence, againft the object which excited it; or, if the particular object cannot be come at, in many inftances, againft any other animate, or even inanimate being, until the unruly energy, is exhaufted by exertion, and it fubfides. That anger exifts in an over tenfe, and hurried ftate of the nerves, is further evident from this, that the ftrength and activity of all animals, is greatly increafed thereby, and the defire of violent exertion is fo great, that fome perfons, and brute animals, if they can find no other object, to exhauft the indefcribable, irkfome, painful, and hurried energy upon, they will exert violence upon themfelves, to eafe their pain.

That quality of the nervous fyftem fubjecting it, to fuch energy, feems to have been beftowed, for the purpofe of felf-prefervation; and is continued by the animal foul, with force fufficient to repel, or overcome the threatened or experienced injury; but its violence is too often mifapplied. More clearly to comprehend the difordered

operations of the ſenſorium, in the deranged ſtate now to be conſidered, it ſeems neceſſary, briefly to reflect, on the healthy, and undiſturbed ſtate of the ſame. An explanation of the modus opperandi, in the proceſs of memory, has been attempted; but ſome recapitulation appears neceſſary.

When vibrations, that are produced by exciting powers applied to the nerves, are communicated to the ſenſorium, in a healthy ſtate, all the nerves of which it is compoſed, inſtantly perform whatever is for the well being of the animal economy; and every nervous fibre thereof, is ready to revibrate, the vibrations that have been before therein excited, and which have now for a time, been ſuſpended; i. e. the matters or things, that have been before ſenſed, are again remembered, which have now for a time, been forgotten. And thoſe nervous fibres, are alſo ready to be moved to vibrations, by thoſe next adjacent to them; i. e. recollecting one matter, cauſes the recollection of another, that has affinity thereto, or is connected therewith; and which is indiſpenſibly neceſſary, to continue a regular chain of rational actions.

In fine, all the nerves compoſing the ſenſorium, when in health, are in a ſtate to be moved to vibrations, by which the law of

ſenſibility is excited, whether moved thereto, from without, through the medium of the organs of ſenſation, or by reflections within the ſenſorium, the regular performance of which, is the eſſence and operation of memory, and is that which conſtitutes a ſound mind, or ſound memory.

Different indeed is the ſtate of the ſenſorium, in the diſorder of which we are treating. By obſerving the ſymptoms and the variety of the appearances exhibited by maniacks; and comparing the whole, with other phænomena, it appears evident, that from ſome cauſe or cauſes yet unknown, part of the nerves compoſing the ſenſorium, are deficient in action, that although, they in general obey the will, yet, they are either generally too torpid, readily to revibrate thoſe ſuſpended vibrations, which had become familiar to them by habit; i. e. to recollect thoſe occurrences which had been often recollected; but it appears altogether evident, that it is a part only that are torpid, for there is an extraordinary power of muſcular exertions, as well as the moſt apt and ſprightly wittineſs at times, and on certain occaſions; which muſt be the effect of extraordinary tone and activity, of ſome of the nerves at the ſame

time, that others do not vibrate, to excite the law of ſenſibility, or to renew memory of matters forgotten.

And it alſo appears, to be one of the regulations of the animal economy, that in a ſtate of health, there muſt exiſt a certain degree of energy, * juſtly diſtributed to all the organs, by which proviſion, when one eye has loſt the power of viſion, the energy before exhauſted upon that eye, is applied to the other, by which its acuteneſs is increaſed; which idea ſeems to be ſupported by obſervation. So alſo. when an occupation requires powerful and conſtant exertions of particular muſcles, the accompliſhment thereof, is at firſt tedious and painful; but by habit, there is an accumulation of energy, by which the exerciſe is borne with eaſe, which is further evident, from the great increaſe of ſtrength in the muſcles, by habitual exertion.

It appears evident, that the direct cauſe of mania, is a ſuppreſſion of vibratory ac-

* By energy is not meant a newly discovered law of nature, but a greater or less degree of tone, and power of sensibility of the nerves; for as long as there is life in a part, its nerves are not destitute of energy; and when it is said there is an accumulation of energy, it is meant that the nerves are in a proportionately higher state of tone, and possess a proportionably greater power of sensibility.

tivity, * or at leaſt, ſurpreſſions at periods, more or leſs remote, of that power in many of the nerves of the ſenſorium, by which there muſt be an accumulation of energy, which muſt operate on thoſe nerves that are ſuſceptible of its operation, and when to them applied, produces that diſagreeable, irkſome, and painful ſenſation, that is experienced in provoked anger; and which is doubtleſs, in all reſpects, as tedious to be endured; and can be ſuddenly relieved only by exhauſting the over aboundant

* It cannot be a suspension of the operation of the law of sensibility simply; for that law is only the effect of vibration. But without doubt there is a certain state, or formation of the nerves, which is necessary to, and which does constitute and enable them to become the centre of the law of sensibility; and without which, they cannot possess it; and which particular mode or state of existence, may at times be wanting or deficient; and, notwithstanding the nerves have power to, and do vibrate; there may be a want of sensibility, but which in reality, is a want of that certain state or mode of the nerves; for the possession of that law of sensibility, is the never failing consequence of such state; although it may operate only when excited thereto by vibrations; therefore, it must be a want or deficiency of that state or mode of existence, or of vibrations, for when neither are wanting, or deficient, sensibility is as unavoidable, as the decent of a body by the law of gravitation when unimpeded, or the movement of the needle by polar attraction. For when steel is so modified as to become the centre of the law of polar attraction, it unceasingly possesses it until its mode of existence is changed.

energy by violent exertions, or by greater pain, or the fear of greater pain otherwise inflicted; which in all cases, shortly exhausts nervous energy: either of which proves a final cure for the present paroxism of provoked anger. But when from a disordered state of the sensorium, the cause of accumulated energy, still continues; although it is exhausted, it will soon again accumulate, and be attended with the same consequence; and this agrees with common observation for the maniac rages and rests alternately. So also, in canine madness, the dog raves by turns, and the same may be observed in all fits, that are attended with incoherency of ideas.

Their causes being different, together with the incoherency of ideas in, and lengthy continuance of unprovoked madness, shews a great difference in the two kinds; but their operations and effects on the nerves and muscles, seem only to differ with regard to the object on which to vent their rage. In that caused by provocation, the revenge is directed against the object that gave the offence; but, the unprovoked, being only an over supply of energy, seeking vent, will most readily be disposed to those nerves, which are most in a habit of motion; i. e. those that have been excited through the medium of the eye and ear,

by the rays of light, reflected from, and undulations of air, by thofe perfons with whom they are moft familiar, and who are the moft agreeable, or by whom the nerves have been excited, in any other way or manner; for thofe nerves will not only be the moft frequently moved by direct operations of light, &c. from thofe perfons, but will be re-excited oftener than any other; i. e. more repeatedly remembered when not prefent, than any other objects by which the mufcles that turn the eyes, or difpofe the body, towards thofe perfons, have been frequently and often, and almoft continually moved thereto. Wherefore, the redundant energy, will fpontaneoufly attach to thofe nerves that actuate or move thofe mufcles, and not only the mind but the movements of the body, will now be toward thofe people; but, regularity of thought being loft, the movements will be like an ungovernable torrent with violence dangerous to thofe perfons, to whom, before they were protection. And the maniac, from the unfoundnefs of his memory even deprives his beft friend of life, without knowing it is his friend, which he kills, as one who had fhot through the body a beloved mother, who expired in a few moments; who, in a more lucid interval of madnefs, being afked why he fhot his mother, anfwered, he thought it was a partridge

on a tree that he ſhot at. And this agrees with common obſervation, for deranged perſons are moſt ſpiteful toward their beſt, and moſt eſteemed friends.

There could not have been a more expreſſive term for this diſorder, than that of non ſane or unſound memory; for it exiſts ſolely in a diſorded or unſound memory; i. e. a defect in ſome of the nerves to revibrate, or in other words, to renew the operations which had been before produced in the ſenſorium, by the irritations of external ſubſtances, through the medium of ſome of the organs of ſenſation, or by the vibrations of adjacent nerves, by which the ſuſpended law of ſenſibility ought to be again excited to operation; or, in yet other words, refuſing to act the ſame thing over again, which renewal alone, without any other matter, mode or operation, is memory; which comprehends all, and every part of knowledge, poſſeſſed by any animal: on the regular operation of which, the regular or rational operation, procedure or conduct, of all animals depends, all which, will be diſtracted, deranged, irregular or incoherent, exactly in proportion as the memory is defective; they are therefore conſidered as one diſorder, operating in different degrees.

It would be extremely agreeable if from the foregoing theory there could be inſtantly deviſed an infallible remedy; although that is not the caſe, yet it cannot be denied but the nearer we arrive to a juſt knowledge of the caſe, we are the more likely eventually to obtain the wiſhed for arcanum.

HYDROPHOBIA, &c.

This appears not an innate diſorder of mankind, but is in all caſes the effect of extraneous poiſon, topically introduced to the fleſh; the great length of time it ſometimes remains without any apparent operation, is not a little ſurpriſing and unaccountable; but it appears moſt probable that it is rarely, if ever introduced to the cavity of an artery or vein; for either of them if not confined or powerfully diſtended, will roll from under the point of a ſharp lancet. Therefore, the tooth of a dog, or of moſt other animals, can but hardly be made to perforate their coats, but muſt paſs by the ſides thereof, or between two of them, and the quantity of poiſon that is not wiped from the tooth, by paſſing through the ſkin, is but ſmall; unleſs the ſkin and fleſh are much torn, and the

veſſels thereby broken, by which the empty extremities contract and withdraw into the fleſh, and circulating no fluids, can convey no poiſon; and if, into a large wound, a quantity of the deleterious ſaliva, ſhould be caſt; the free diſcharge of blood, &c. would probably waſh it from the wound; but if in fact, the poiſon is conveyed into the cavity of the arteries or veins, and mixed with the circulating fluids, it is probable the vis vita will overcome and deſtroy its poiſonous qualities, and expel it from the body; for it does not operate directly like arſenic, &c. but muſt like corn planted, or the miaſmata of the ſmall pox, meazles, &c. die and produce a new crop, before it operates in another body, than that which produced it; and for that purpoſe, it ſeems it muſt be depoſited in thoſe humours that are in a torpid ſtate, of which it has power to coagulate, and confine a ſmall portion for a longer or ſhorter time, according as the particular ſituation is more or leſs favourable to its continuance, which in ſome inſtances, is for a long time; but eventually by fermentation, or ſome other operation, the confined fluids are attenuated, and by abſorption received into the veins and arteries, with the circulating fluids. And, by ſubſequent operations, it ſeems, they are peculiarly prepared to be, and are chiefly

depoſited in the ſalival glands; which alſo more fully appears, from the great quantity of ſaliva or rheum, diſcharged from the mouth, and which contains the poiſon by which the diſeaſe is communicated.

On the nerves, of what part of the body the irritation of the poiſon is exerted to produce that incoherency of ideas, and ungovernable deſire of muſcular exertion which ſeems not in the leaſt to differ from mania, is doubtful but from the ungovernable deſire of biting, it is probably upon the nerves in the glands of the mouth, fauces, &c. for there appears no reaſon, why the operation may not be local, in this as well as in many other diſorders, whoſe effects are general.

This being ſimply the effect of a ſpecific poiſon, independent of conſtitutional defects, or error of conduct; no one ought to doubt, but a ſpecific and infalliable remedy, will be eventually diſcovered. Therefore, phyſicians and others, ought to make every experiment in their power, not only on the human ſpecies, but upon dogs and other animals, to attain the wiſhed for diſcovery, and whatever is propoſed with probable appearance of propriety, as a remedy, ought not to be ſlighted, but to receive

that attention, which may decide with certainty concerning its merit.*

* It is probable that the flesh sloughing of around the wound together with a plentiful discharge of matter from the same, may, in some instances remove the poison therefrom; therefore, to encourage the discharge may be useful. but if the foregoing theory is correct, extirpating the flesh around and quite to the bottom of the wound may be of the greatest consequence.

Considering the powerful operation of Copper, Mercury, and opium, and the information concerning the following which I have received, and the importance of discovering a remedy for the above disease also, that the General Assembly of the State of New-York, (where its efficacy is asserted to have been experienced for more than twenty years,) have taken so much notice of it as to grant a compensation to John M. Crous for discovering and publishing the following prescriptions for the cure of hydrophobia, &c. I take the liberty to subjoin the same—" Cure for the bite of the mad dog.

" The following is an account and prescription of the remedy and cure of the hydrophobia or canine madness, made by John M. Crous, in conformity to an act of the legislature of the State of New-York, passed at their present session, viz.

" 1st. Take one ounce of the jawbone of a dog, burned and pulverised, or pounded to a fine dust.

" 2d. Take the false tongue of a newly foaled colt; let that also be dried and pulverised—and

" 3d. Take one scruple of the verdigrease, which is raised on the surface of old copper by laying in moist earth; the coppers of George I or II are the purest and best. Mix these ingredients together, and if the patient be an adult or full grown, take one common tea spoonful a day, and so in proportion for a child according to its age; in one hour after take

NERVOUS DEBILITY, OR LAXITY OF TONE.

The effects of which, may be tremor, universal weakness of the muscles, faintness of the vital organs, mental gloomi-

the filings of the one half of a copper of the above kind, if to be had; if not, then a small increased quantity of any baser metal of the kind—this to be taken in a small quantity of water.

"The next morning fasting, (or before eating,) repeat the same as before. This, if complied with, after the biting of the dog, and before the symptoms of madness will effectually prevent any appearance of the disorder; but if after the symptoms shall appear, a physician must immediately be applied to, to administer the following, viz.

"Three drams of the verdigrease of the kind before mentioned, mixed with half an ounce of calomel, to be taken at one dose. This quantity the physician need not fear to administer, as the re-action of the venum, then diffused through the whole system of the patient, neutralizes considerably the powerful quality of the medicine. And secondly, if in four hours thereafter the patient is not completely relieved, administer four grains of pure opium, or one hundred and twenty drops of liquid laudanum.

"N. B. The patient must be careful to avoid the use of milk for several days after taking any of the foregoing medicines." JOHN M. CROUS.

It may not be amiss to observe, that copper is corroded to verdigrease by acid, or that which is sour; and therefore, if the verdigrease meets with acidity in the stomach, it may possibly corrode it to a costic quality, which the stomach cannot bear: and burned bones, oyster shells, or some other anti acid may be necessary; but the bone of a dogs jaw, is no better than that of an asses.

nefs, and the moft diftreffing melancholy, bearing down the foul of the unhappy fufferer; into which, the unclouded fun fhowers infupportable defpair.

As this difeafe but feldom proves fatal, although it may continue for years, it is by the unfeeling, thoughtlefs, and ignorant, vulgar, denominated hypo, or hypochondriac, and the patient treated with derifion. But there is no other human ftate, which fo mnch merits and demands the compaffion, of all who are not devoid of every human emotion.

Happy indeed, is it for fuch unfortunate fufferers, who have friends, that will not forfake them in their diftrefs.

ADDITIONAL THOUGHTS.

On what does the explofion of gun-powder depend?

Evidences and arguments are fufficiently numerous, fully to prove, that the explofion of gun-powder is nothing more or less, than the rarefaction of water.

The fpecifick gravity of water is nearly as 1 to 1000 of air, (although not exactly

ſo, it will be convenient ſo to expreſs it, in the following obſervations,) but before a corpuſcle of water, can float in air, it muſt become as light as a particle of air; for which purpoſe, the particle of water muſt occupy a ſpace, 1000 times more extenſive than in its natural ſtate.

Clearly to underſtand the operation, it ſeems neceſſary to have correct ideas of fluidity and exhalation.

The conſtituent principle of fluidity is the ſame in all fluids; but water is now the ſubject of inveſtigation, and from its tranſparency, incompreſſibility, and many other circumſtances and appearances, its corpuſcles are evidently ſpherical, homo genious and impenetrably hard.

To every particle of which is annexed, an invariable law of repulſion, whoſe power in its natural ſtate, extends no further, than to prevent all contact of particles, and which is perfectly uniform in its extention, by which the particles are kept when unagitated, in regular lines, that the rays of light may have free paſſage in all directions. Its tranſparency is full demonſtration of the homo genioufneſs of its particles; and alſo, of the equal extenſion of the law, or power of repulſion which

they poſſeſs. Its incompreſſibility is e dence of the hardneſs of its particles; a alſo, that the law or power of repulſi which conſtitutes its fluidity, extends further, than to prevent their touchin but which no force or power can overcome or depreſs; for if it could be depreſſed, water would be compreſſible; and if its particles could be forced together, its fluidity muſt ceaſe. In theſe laſt reſpects, it differs widely from air, whoſe conſtituent law of fluidity is nearly 1000 times more extenſive than that of the particles of water; by which extenſion, it may ſuffer great depreſſion, without endangering its fluidity, or apparently leſſening its tranſparency.

This law of repulſion, annexed by the creator to each corpuſcle of water, is that, without which, there could have been no fluid whatever; but, united to the corpuſcles of water, is not only the cauſe of its fluidity, but is alſo the cauſe of many other operations, without which, creation would have been imperfect; by its power, when excited to operation, the rarefaction of water is produced, which ſeems nextly, to require explanation.

It has been obſerved that the repellant power, annexed to the corpuſcles of water in its natural ſtate, extends no further,

than to prevent the contact of particles; but it is evident from many obſervations that the aforeſaid repellant power is capable of very great extenſion, which may be excited by a variety of operations. The agitation of air, or wind, whether natural or artificial; as a ſtrong current of air from ventilators, driven over the ſurface of large ciſterns of water, in manufactories for ſalt, &c. But fire, above all other things, excites the extenſion of the repellant power of the particles of water.

It has been obſerved, that the ſpecific gravity of water, is to air, as nearly 1000, to one; yet there is no poſitive proof that particles of water are larger than thoſe of air, nor do I conſider the experiment, by which it appears that water may be forced through the pores of gold, and that air cannot, is any proof that the particles of water are finer than thoſe of air; for the much more extenſive irreſiſtible law of repulſion, poſſeſſed by the particles of air, than by thoſe of water, is conſidered fully ſufficient to prevent the paſſage of thoſe of air through gold, although they ſhould be much finer than thoſe of water. The probability ſeems to be, that thoſe of air are fineſt; but, I know of no reaſon, why the fact ſhould be conſidered very material.— It is enough for the preſent purpoſe, to

know, that a cubic foot of water is nearly as heavy as 1000 cubic feet of air. Therefore, as before observed, water must become 1000 times lighter, than in its natural state before it can float in air; to produce which, it must occupy 1000 times more space by the rarefaction of its particles, than in its natural state; but the solid substance of the particles of water is incompressible; therefore, they cannot themselves expand; but the repellant power united to them, must be excited to an extension sufficient for the requisite purpose.

The process seems to be as follows, when water and fire are brought into contact, there is in no instance a truce; for such is their opposition, that one or the other must be completely repelled; if there is sufficient water, all fire that is in activity will be extinguished; if the fire exceed, the water must be evaporated, and the more sudden the mixture, the more immediate the effect.

It appears from observation, notwithstanding the opposition which exists between fire and water, that when, by the operation of fire, the repellant power of a particle of water begins to be extended, that particle instantly becomes an attractor of the particles of fire; and forthwith at-

tracts, to within its ſphere of repulſion, as many of them as are ſufficient to ſaturate it, if ſo many are within its power; when the redundant particles operate on other particles of water, or rebound among them in the ſame manner, as they do among the particles of iron, or other ſubſtances; for, as long as the repellant power of the particles of water remains in its condenſed, or cloſe ſtate, it reſiſts the operation of the particles of fire, until there is a conſiderable accumulation thereof, among the particles of water; but, when the repellant power of a particle of water begins to be extended; the particles of fire find no further reſiſtance, and readily attach themſelves thereto, until the particle of water is ſaturated therewith, and that the accumulation of heat, in water, contained in an open veſſel, can by no means be made to exceed 212 degrees; for when accumulated above that degree, the heat inſtantly rarefies every particle, which muſt immediately exhale; by which operation, the irreſiſtible repellant power of every particle of water is expanded to 1000 times its natural ſize, by which they become of nearly the ſame ſpecific gravity of particles of air, or ſomething lighter than thoſe at the ſurface of the earth, by which they aſcend to a medium where they are ſuſpended, and are the only ſource of rain,

A drop of water, let fall into glowing embers, where it is instantly rarefied and exhaled, makes an audible report.

I once took into my hand an iron, with a handle of wood six feet in length; it was night, and the iron was wet with dew, to which I did not attend: a workman, had laded the melted potash from a kettle; I applied the wet scraper, to gather the remains of the potash, to the bottom of the kettle; at the first touch, the edge might emerge a quarter of an inch into the potash glowing with a red heat; the explosion was as sudden as the discharge of a gun, and the report almost as loud, nor did my eyes but just escape the drops of melted potash, which passed my face resembling stripes of fire, with nearly the celerity of shot.

Pulvis Fulminance, (thundering powder) composed of saltpetre 3 parts—sal. tartar 2 parts, and brimstone, one part, of which a heaped tea spoonful, being placed on a shovel, and set over a fire, first melts, after which it at once all explodes, with a report equal to a well charged musket: this exceeds any gun-powder in strength, but does not explode until after melting; therefore can be no substitute for it.

Another mode of bringing fire and water to operate on each other, merits attention. To prove before finishing, whether a gun-barrel is sound, containing water, let both ends be made tight with plugs, place it over a fire, so that it may heat in the middle, when the caloric penetrates, rarefaction begins in the water; by the irresistible power of which, the water will be forced through any unsound places, if such there are; if not, by an increase of heat, the plugs if not too fast, will be forced out; but if there is no breach and the plugs do not give way, when the heat is sufficiently augmented, the barrel must burst where the iron is sound.

There are innumerable ways of bringing fire and water into contact, so as to cause explosion; but it is thought enough have been mentioned. In all the a-

bove experiments, it is evidently the extension of the law of repulsion, that is annexed to the particles of water; and is operated upon by the particles of fire, which produces the explosion.

That it is the extension of the law of repulsion annexed to particles of water, appears evident from this, that in the first experiment the whole quantity of coal and saliva, must be mixed at once, and are both almost entirely dissipated by the explosion; and that neither the fire nor water alone, when struck as above produce any extraordinary report. It is therefore evidently, the snddenly mixing of the two, by which one powerfully operates on the other, and that it is the one operated upon by the other which explodes; that it cannot be the fire which is expanded is evident from this, that fire easily penetrates all bodies, but does not enlarge their volume any further than it excites an extension of the anti-crouon, or power of repulsion they possess, which it has the power of doing in almost all things; for steel, ston.s. earth, &c. expand and become fluid by the opeartion of fire, and its operation is exactly the same in all other things, as in water. in proportion to the anti-crouon their corpuscles possess.

In the experiment of the gun-barrel, if filled with air instead of water, the effect must be in proportion to the difference of power of rarefaction, which air and water possess, and if it should contain neither air nor water, the fire could have no effect upon it.

And from all appearances, and every observation it is evident that it is not the fire which is expanded, but it is the fire which has power to enlarge the volume of all bodies, but water beyond all others.

That it is the water which is expanded. is demonstrated by exhalation, for there needs no argument to prove, that a heavier body cannot spontaneously ascend through a medium 1000 times lighter than itself, which is nearly the odds between air and water; and that to enable the corpuscles of water, to ascend into the air, they must occupy 1000 times more space,

than in their naturhl state; which, when instantaneously produced, is all that is necessary, to propel the ball from a cannon. And as we have no evidence that any other substance but water possessess such power, and have conclusive proof that water does, it seems unnecessary to look for it in any other; for we have few things in greater abundance.

It appears probable that the repellant power annexed to the corpuscles of water, is capable of an extension from its natural state beyond that of the corpuscles of air, in proportion to what they each possess.

It may however be otherwise; but having no conveniences for the purpose of making experiments, it is not in my power to ascertain the fact. However it may be, they were each of them created so as to answer every purpose for which they were designed.—And that the nucleus or solid centre of a particle o water, was at creation constituted, so forcibly to confine its law of repulsion, that, without the operation of certain powers, it should extend no further than to prevent any contact of particles; but that they should remain so irresistibly fixed asunder, that a volume of them cannot be compressed to a degree that may be perceived. And whether the repellant power of particles of water may be extended in proportion to quantity, more than that of particles of air, or not. It is so constituted, that by the application of the aforesaid powers, it is capable of extending to a degree which enables them to rise in air; by which rarefaction, a number of indispensable purposes in nature are accomplished.

And it seems that for the purpose of keeping the corpuscles of water, irresistibly asunder, when so closely situated; it was necessary, (if one may be allowed so to express it,) that the repellant power thereof, should be much denser than that of the particles of air; whereby it must not only resist more powerfully, but when rarefied extend a far greater distance, in proportion to the space they each occupy before rarefaction.

INDEX.

B

INDEX TO THE APPENDIX.

The reader is requested to correct the following erro in the Appendix

Page 2, line 7 from bottom, for *agree* read *agrees*.
40, note, line 8 from bottom, for *conceffion* read *conception*.
41, note, line 11 from top, for *goes* read *does*.
44, line 17 from top, for *poffeffes* read *poffeffing* and dele *the*.
48, line 4 from bottom, read *and prevents a*.
63, note, line 9 from bottom, for *caufes* read *cafes*.
76, line 4 from bottom, for *opithotonos* read *opifthotonos*.
78, note, line 11 from bottom, for *zigor* read *rigor*.
79, line 9 from bottom, for *voluntary* read *involuntary*.
81, note, line 1 and 2 at bottom, after *or*, read *producing i flamation in the injured part, by fcarifications and ftimulants.*
82, note, line 6 from bottom for *bas* read *have*.
In the body of the work, page 27, line 13 from top, for *as* read *c*.